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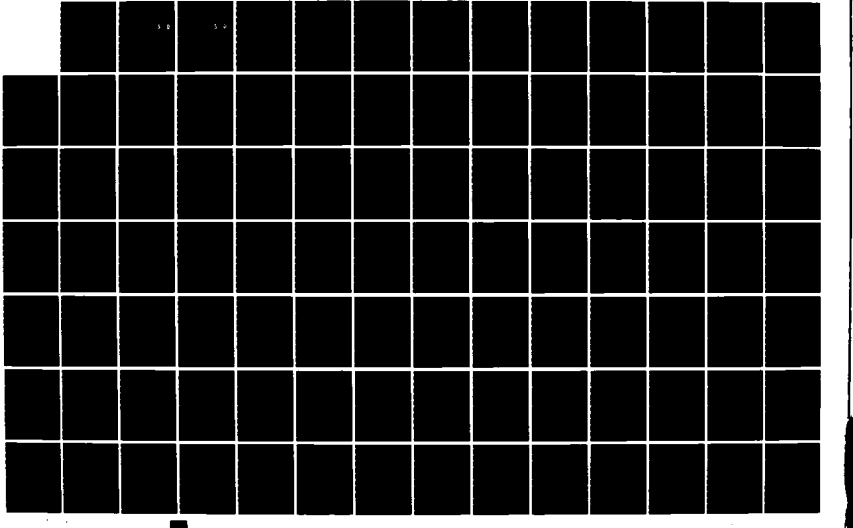

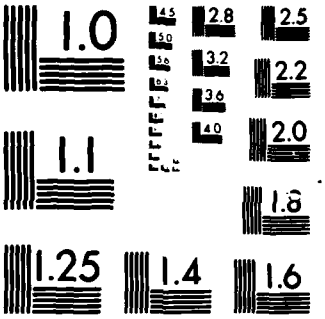

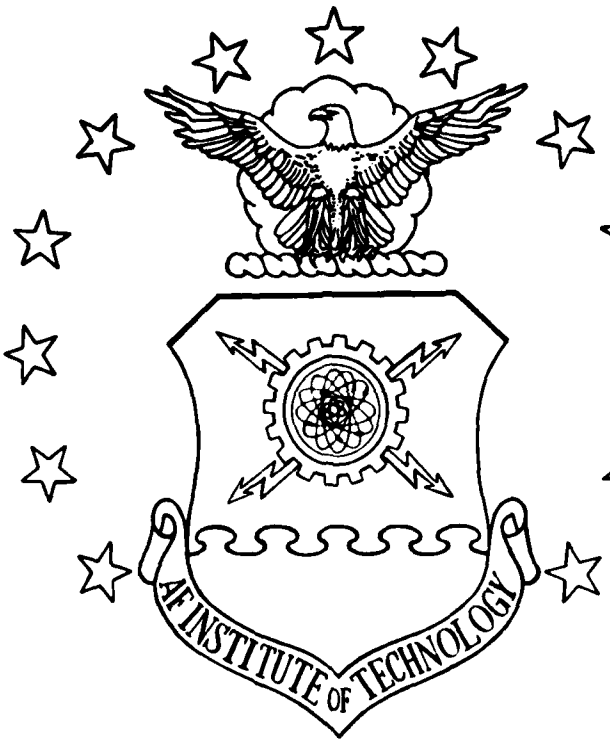

COMPUTER ASSISTED INSTRUCTION FOR THE "C" PROGRAMMING LANGUAGE ON THE ZENITH Z-100 MICROCOMPUTER SYSTEM

THESIS

Frank W. DeMarco
Captain, USAF

AFIT/GCS/MA/85D-2

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(1)

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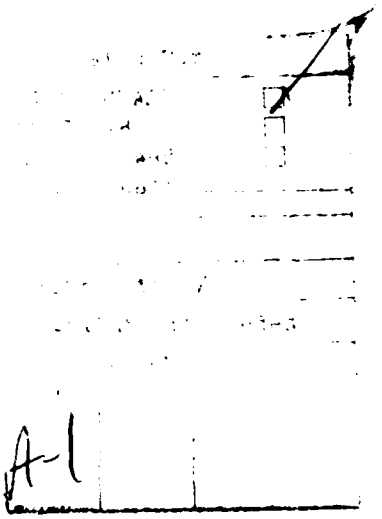
THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science

Frank W. DeMarco, B.S.
Captain, USAF



December 1985

Preface

The purpose of this study was to develop a computer assisted instruction (CAI) program package for use on the Zenith Z-100 microcomputer system. The package is designed to give programming students introductory information on the "C" programming language. This programming package is to be used in the training programs managed by the Computer Assisted Instruction Plans Branch of the 3300 Technical Training Wing at Keesler AFB, Mississippi.

I would like to express my sincere thanks to my thesis advisor, Dr. Henry B. Potoczny, who gave me guidance and encouragement throughout my thesis effort. Thanks is also extended to Captain Patricia Lawlis, who as my thesis reader provided many constructive comments on improving this thesis. Grateful appreciation is also extended to the sponsor my thesis, the CAI Plans Branch at Keesler AFB, and in particular, Captain Glen A. Miller and Technical Sergeant Charles T. Neal, who provided help in the verification and validation of the programs and course material I developed.

Finally, I want to express special gratitude to my wife Anne and my children Crystal and Bryan. They have forfeited countless hours of time with me in order that I could complete my graduate work here at AFIT. Their patience, understanding, and devoted love gave me the strength I needed to overcome the many obstacles I encountered. I owe them a debt that will take a lifetime to repay.

Table of Contents

List of Figures

AFIT/GCS/MA/85D-2

Abstract

The field known as "computer assisted instruction" or "CAI" as it is commonly called, has gained considerable interest and support since the advent of the microcomputer. More and more people, including those in supervisory positions are beginning to see the advantages, both cost and time, in having training available in the workplace. This ~~study~~ developed a training package for use on the Zenith Z-100 microcomputer. The package consists of six lessons and three programs. The six lessons cover various topic dealing with the "C" programming language. The objective of these lessons is to present a introduction to the "C" programming language. The three programs are written in the Pascal programming language and are used for the following functions:

1. Provide a means of displaying the lesson material.
2. Provide a means of checking student progress.
3. Provide a means of displaying course statistics.

Computer Assisted Instruction for the "C" Programming Language on the Zenith Z-100 Microcomputer System

I. Introduction

Background

The use of Computer Assisted Instruction (CAI) to help in the training needs of the Services has increased with the introduction of microcomputer systems into the workplace. The development of CAI courses for use on these computer systems has been lagging behind the need for training on the new systems. The CAI development process involves a working knowledge of the system to present the material as well as a knowledge of the subject to be presented. The presentation of the developed CAI course is usually controlled by means of some type of presentation program. Manpower and time constraints may prohibit development of such a program and indicate the need to utilize a commercially developed authoring/presentation system.

The use of a commercial authoring system requires that a coursewriter learn that specific authoring system for use on a specific microcomputer system. The coursewriter can then devote his attention to the development of the course subject material. The subject topics that typically are identified as of primary importance include: word processing, data base management, spreadsheets, operating systems, and programming languages.

Statement of Problem

The problem to be solved is as follows: How can a computer assisted instruction (CAI) course be written and implemented to teach the "C" programming language on the Zenith Z-100 microcomputer system without the use of a commercial authoring/presentation system? The course will be of sufficient length to instruct the beginning student to a level that will allow him/her to program using the "C" programming language. The course subject will be broken into lesson topics which are made up of subsections of the lesson topic.

Each lesson will:

1. Give the student the ability to select between being shown the complete lesson or only reviewing certain parts.

2. Have the ability to sample student comprehension during lesson presentation by means of questions.

3. Have the ability to branch, at appropriate times, to other parts of the lesson.

4. Give the student a chance to review subsections before being tested on the lesson material.

5. Have the ability to test the student on the presented material after lesson completion.

6. Have the ability to allow for review of subsections before retesting (in the case of lesson failure).

In addition to the above, a record will be kept of student responses, both during the presentation of the lessons and the tests, for later statistical analysis and

display. This is done in order to be able to identify areas of the course that perhaps are not teaching the material as intended and/or are causing the student difficulties.

Scope

The scope of this thesis effort is to design, implement, test, and validate a CAI course for presenting information on the "C" programming language. The design phase will incorporate top down structured programming techniques.

Although it is not the primary purpose of this thesis, a method for developing the textual material and presenting that material will necessarily be created. This added benefit arises from the fact that no commercially available authoring/presentation software will be used. This opens up the possibility of developing other courses using programs written during this thesis effort.

The end result of this thesis is to develop a CAI course that will be acceptable to the sponsor at Keesler AFB, who will then distribute the course to all interested training managers throughout the Services.

Assumptions

It is assumed that the students who will use this CAI course will have a working knowledge of the operation of the Zenith Z-100 microcomputer system that this course is designed to run on. This Z-100 system is the standard system purchased by government contract through Zenith Data

Systems, namely, the 192K byte, two 5.25 inch disk drive system. Although it would be of some benefit, there isn't any requirement that students taking this CAI course have access to a "C" compiler.

General Approach

The first step in this endeavor is to do research into the techniques of teaching with a computer. The purpose here is to broaden the teaching base from which to build the overall course presentation. Once the methods of presenting the material are well in hand, the course material will be researched to establish a firm background from which to teach. The next step is to write the individual lessons and develop the program to present them. A program will then be developed to do the statistical analysis and display.

Following the research and development phase will be the implementation of the system. This phase will consist of putting all the pieces into a cohesive package that will accomplish the goal of the study, namely, use the Zenith Z-100 computer system to present a CAI course on the "C" programming language.

In order to ensure the development and implementation of a quality product, an extensive testing and validation system will be incorporated throughout the study. The ultimate test will come when the sponsor at Keesler AFB tests the course against their well-established standards.

II. Methodology

The Aim of CAI

The overall aim of Computer Assisted Instruction (CAI) is, naturally, to use a computer system to assist in the training of individuals in a given subject.

In its most common form, CAI is very similar to a programmed text. The subject material is presented to the student, questions are asked of the student, answers are evaluated, and a decision is made as to what material is shown next. If the questioning indicates that the student understands the material, new material is shown. If the student seems to be having trouble with a particular part of the lesson, a branch can be made to supplemental material to help the student understand. Other forms of CAI use simulation and/or emulation techniques. These methods of instruction are very useful when teaching a specific performance process but not for such things as computer programming. Since it is the intent of this thesis effort to teach a programming language, the method used will closely resemble that of programmed text.

Advantages of CAI

There are many advantages to CAI, the following are but a few of the more important ones: Standardization, time efficiency, availability, flexibility, modularity, and cost efficiency.

Each of these advantages contribute to the overall attractiveness of using CAI as a method of training. Standardization is accomplished by programming the subject material into the computer. In this way, each and every student who takes a given course will receive the same information. The unfortunate human flaw of a human teacher forgetting to mention some important detail is thus avoided.

The use of CAI can save time by allowing students to progress at their own rate. This is opposed to the alternative of locking them into a classroom setting and controlling the pace of the class as a whole. This leads us to another of the advantages, that of availability. Since the CAI course is conducted on a microcomputer system, the course is virtually available at all times. This means that many training requirements can be accomplished without the student having to leave his/her work area. Hence you have flexibility (another advantage) in scheduling training. Since the course is available at all times, training can be scheduled around work requirements.

The actual construction of a well developed CAI package should allow for the accessing of information in a rapid way. This usually calls for the development of sections of the course in small modules. In this way the student doesn't necessarily need to complete an entire course to get at the information that pertains to his/her job requirements. The CAI course developed in this thesis follows this modular course concept. The course in broken into lessons

which are each broken into topics.

The last advantage mentioned is that of cost effectiveness. By taking the previous advantages into consideration it is easy to see how using CAI can achieve a cost effective training program. Training can be conducted whenever workload requirements allow the student enough free time to take CAI lessons. The need for the student to travel to some other location for needed training can also be reduced.

Disadvantages of CAI

There are of course drawbacks to everything, and CAI is no exception. A few of the disadvantages follow: System availability, Uni-directional training, acceptability.

The availability of the computer system for training purposes can restrict the usefulness of the CAI system. The primary reasons for system nonavailability are: Operational requirements and maintenance downtime. An organizations operational requirements may be such that a computer system can not be spared in order to accomplish a training requirement in a timely manner. Obviously, if a computer system is down for maintenance, training can not be accomplished using that system.

The second disadvantage involves the inability of the students to ask questions of their trainer. This requires the student to concentrate hard on the presented material in order to ensure the required understanding. Since the student doesn't (usually) have the ability to query the compu-

ter on a point that may be causing him/her problems, the student must seek out someone who knows the subject in order to receive clarification. This of course is not all bad, since this will lead to better communication in the work place.

Lastly, CAI is not completely accepted by management personnel as an alternative to classroom instruction. Formal classroom instruction has been used for so long that many believe it to be the only effective means of accomplishing required training.

Development Considerations

There are several design considerations to take into account when coming up with a methodology for CAI course development. The first of these and perhaps the most important is the objective of what is to be taught. As stated before, the objective of this study is to create a means of presenting information on the "C" programming language on the Z-100 microcomputer system. The second consideration is the resourses available for training. The necessary resources for taking the course developed in this study is any microcomputer system that runs under the MS-dos operating system. The primary system will be the Zenith Z-100. The third consideration is the teaching technique to be used. As stated earlier, this will most closely resemble a programmed text presentation. The last major development consideration is course validation. In addition to initial

development validation, the CAI package will provide a means of recording student progress and provide for statistical collection of student responses to all questions throughout the course. These capabilities will be described in detail later in the study.

Course Development Approach

The general approach to developing this CAI was to write a program which would keep track of as many as twenty students as well as present the material to the student in short topic sessions. The student has total control over which topics he/she views. The presentation program is written in the PASCAL programming language and is easy to modify in the case of any future enhancements. Two additional programs, both written in PASCAL, have been included in the package. The purpose of the first is to produce a report of the current student status for each registered student on a given student disk. The purpose of the second is to produce a report of the statistics collected on the student responses during course presentation. More detailed information can be found in Chapter 3.

III. Design Specification

General Description

The purpose of this computer assisted instruction (CAI) package is to provide a means of presenting introductory information on the "C" programming language. The material to be presented is to be stored in separate lesson files on one five and one quarter inch floppy disk that has been formatted using the MS-DOS "format" program. The lesson files are to be created using any text editor that will run under MS-DOS. The lessons are to be broken into topic sections that the student can complete in a relatively short period of time. Three programs will be provided with the CAI package and a description of these follows.

CAI Program

The main program contained in the CAI package is the one that will present the course material to the student. This program will read and display several files automatically in addition to reading and displaying the student's chosen subject material. This program will keep a record of student progress through the course as well as write to a statistical collection file to be used for future course validation and improvements.

Lesson Files. The main CAI program will have access to six lesson files which contain the course material. Each of these lesson files will contain introductory information for its particular lesson material. An associated menu is also

included for display, allowing the student to choose the topic material to be shown.

Other Files. In addition to the lesson files discussed above, there are five other files to be used by the main CAI program. First, there is to be a file that contains introductory comments to the student. This file will be kept short since it is to be seen each and every time the program is executed. Second, there is to be a main menu file that will allow the student to choose which of the six lessons they want to enter. This file will be restricted to one screen in size. Third, there is to be a file that contains program conclusion comments. This file will also be kept short and is only to serve as a means of assuring the student that they have correctly terminated the program. Fourth, there is to be a file that will store data on as many as twenty students. This file is where each student's progress through the course is to be kept and will be keyed on a unique student identification number. Lastly, there is to be a file that will store data for each question displayed during course presentation. This file will be used for on-going course improvements.

Status Program

The status program will be provided for use by the training monitor. Its whole purpose is to provide a means of viewing each student's record in order to determine their status in the course. A report is to be generated giving

the unique student identification number and listing all lessons that have been successfully passed. The program will allow for the possibility of the training monitor having merged several student record files into one file. The program will also format the report for either screen display or hardcopy printout.

"STUDENT" File. The file to be read by the status program is to contain student identification numbers, student names, as well as lesson and topic status data. An active student file will contain at most twenty unique student records. As mentioned earlier, several student files may be merged into one student file prior to running the status program.

Statistics Program

A statistics program will be provided for use by the office of primary responsibility (OPR) at Keesler AFB. This program is to provide a means of analyzing the data collected on questions presented during each training session. A report is to be generated giving information such as lesson number, frame number, number of responses for each of the valid responses, number of right responses, number of wrong responses, percent of right responses, and percent of wrong responses. The results of the statistical analysis is to be displayed in either of two formats: screen display or hardcopy printout.

"STATS" File. The file to be read by the statistics program is to contain such items as lesson number, topic number, frame number, correct answer, and the student's response. Again, several of these files may be merged into one file prior to running the statistical program.

IV. System Implementation

General Description

The implementation of this computer assisted instruction (CAI) training package involved the development of lesson material covering six major subject areas. The development of these lessons was accomplished in conjunction with the development and validation of the three programs specified in chapter three. This chapter presents a brief description of each major component of the CAI training package. Copies of these components are provided in appendixes B and C.

"C" Lessons Descriptions

The following is a breakdown of the subject material as presented in the "C" CAI course:

Lesson One. Lesson one contains introductory information on the course and some general information on "C" programming. The lesson is broken into four subtopics and a lesson test. The first subtopic gives a short introduction to the overall course structure and some of the particulars used in the course. The second subtopic discusses the overall organization and structure of a typical C program. The third subtopic gives a description of the overall C programming environment covering such items as "compiling" and "linking". The forth subtopic states a problem to be solved and presents a solution to help introduce the student to C program statements.

Lesson Two. Lesson two contains information on variables, constants, operators, and expressions used in C programming. The lesson is broken into four subtopics and a lesson test. The first and second subtopics cover the declaration and use of variables and constants. The third and forth subtopics cover the use of the different operators and expressions in C programming.

Lesson Three. Lesson three contains information on program control statements used in C programming. The lesson is broken into four subtopics and a lesson test. The first subtopic gives descriptions of the structure and use of the "if" and "if-else" control statements and how to "nest" these statements along with a description of the "switch" control statement. The second subtopic discusses the structure and use of loop statements (while, for, and do-while). The third subtopic gives a description of the "break" and "continue" statements and how they are used. The forth subtopic gives a description of the "goto" statement and the use of "labels" within a C program.

Lesson Four. Lesson four contains information on arrays, pointers, and address arithmetic used in C programming. The lesson is broken into four subtopics and a lesson test. The first subtopic introduces the declaration, initialization, and use of arrays. The second subtopic introduces the declaration and use of pointers. The third and forth subtopics cover how to work with pointers and includes topics such as how pointers are passed to functions, how pointers

are used in conjunction with arrays, and how to use address arithmetic.

Lesson Five. Lesson five contains information on structures that are used in C programming. The lesson is broken into four subtopics and a lesson test. The first subtopic introduces the idea of structures and two methods of their declaration. The second subtopic describes the use of structures within structures and arrays of structures. The third subtopic describes how to use pointers in conjunction with structures. The forth subtopic describes how structures are passed between functions.

Lesson Six. Lesson six contains introductory information on input and output capabilities of the C language. The lesson is broken into four subtopics and a lesson test. The first subtopic gives a description of the use of the standard I/O functions "getchar" and "putchar". The second subtopic gives a description of the use of the standard input function "getline". The third subtopic gives a description and examples of the standard input function "scanf". The forth subtopic gives a description and examples of the standard output function "printf".

CAI Program

Program CAI is the program that is used to present the lesson material to the student. The program is designed to present any lesson material that is in the same format as the lessons developed in this thesis. Therefore, additional

courses may be written for presentation on the Zenith Z-100 by this program. The following is a breakdown and brief description of the program.

Structure Charts. The program is broken into a main program and 17 procedures, all of which are written in the Pascal programming language. Structure charts of this program are presented in Figures 4.1 thru 4.8 of this chapter.

Flow Description. The flow of this program follows a very logical structured path. The program begins by presenting an introductory message from file "INTRO". The student is next queried for their unique student identification number. A search is then made of file "STUDENT" (which has been read into memory) and if no match is found (a new student) the student is queried for their name and unique student identification number they wish to use from this point on. Next, the student is presented a menu of lessons from which to choose (file "MENU"). Once a selection is made, introductory information for the chosen lesson is displayed and another menu is presented giving the student a choice of lesson subtopics. Once the student chooses a lesson subtopic, the topic is read into memory and topic presentation begins. When the topic is completed, an update of the CAI statistical collection file as well as the students progress record file is made. The student is then returned to the subtopic selection menu, where if the student wishes, he/she may exit to the lesson selection menu, where if the student wishes, he/she may exit the program.

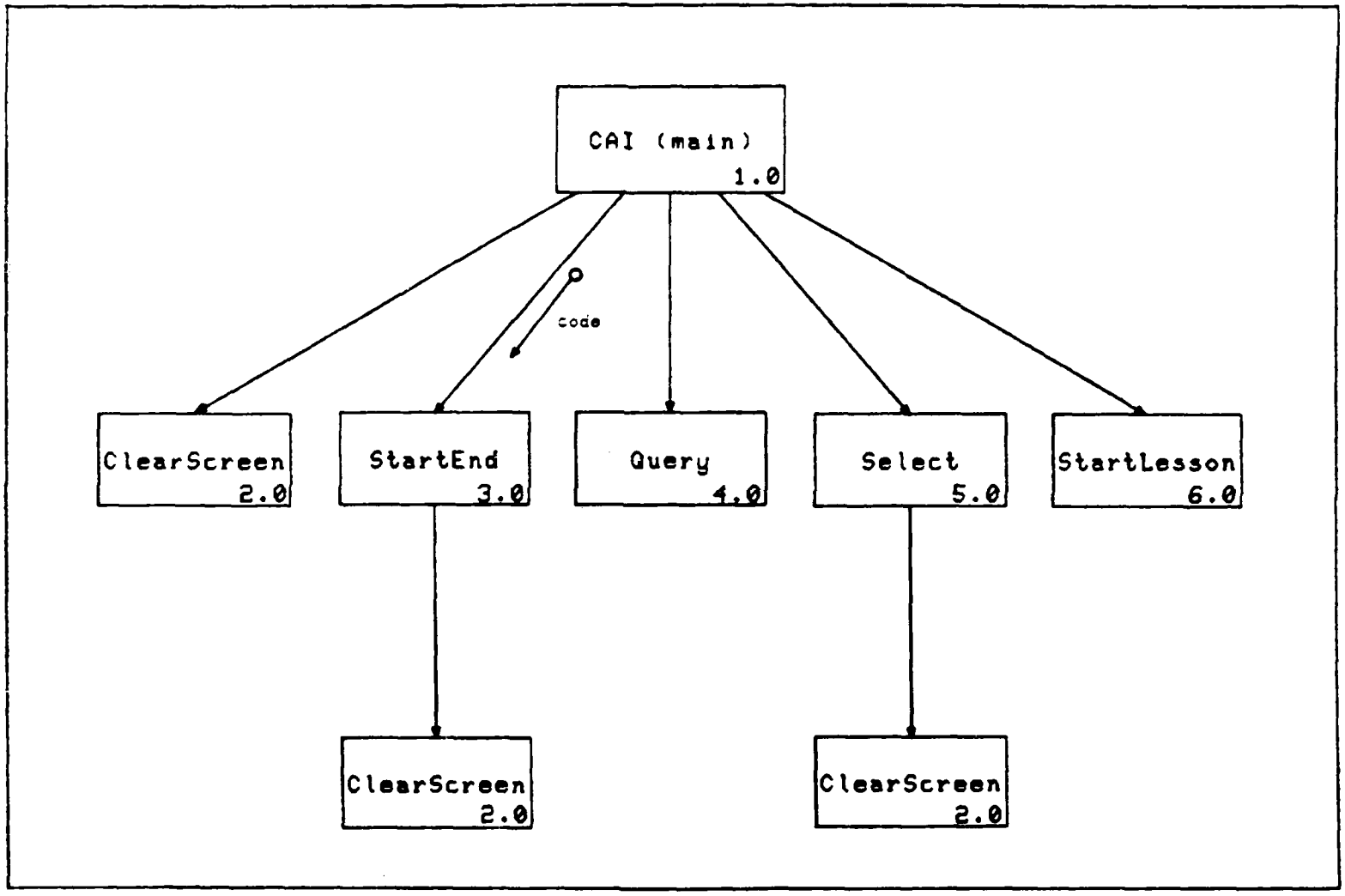


Figure 4.1 CAI - Main

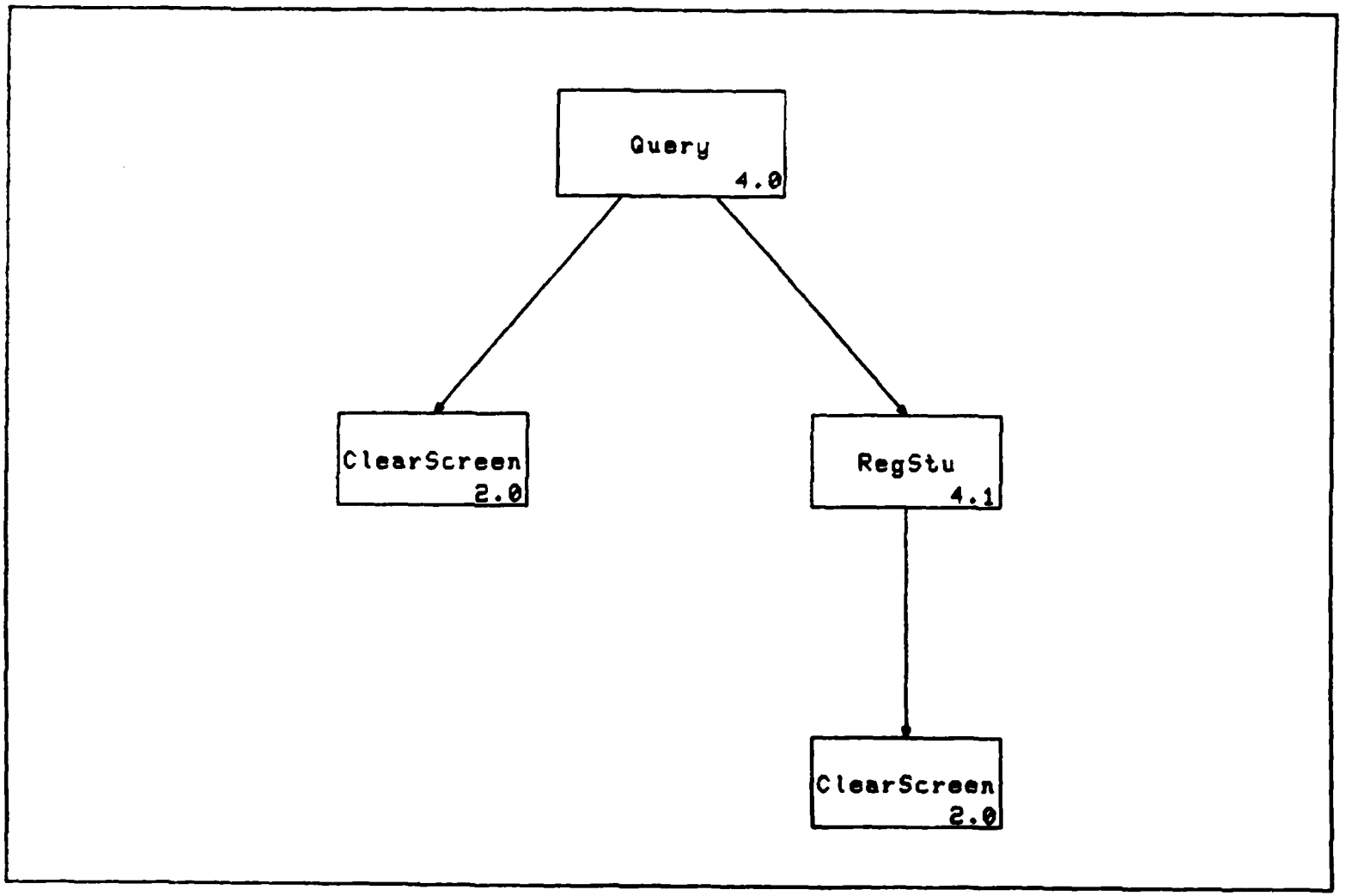


Figure 4.2 CAI - Query

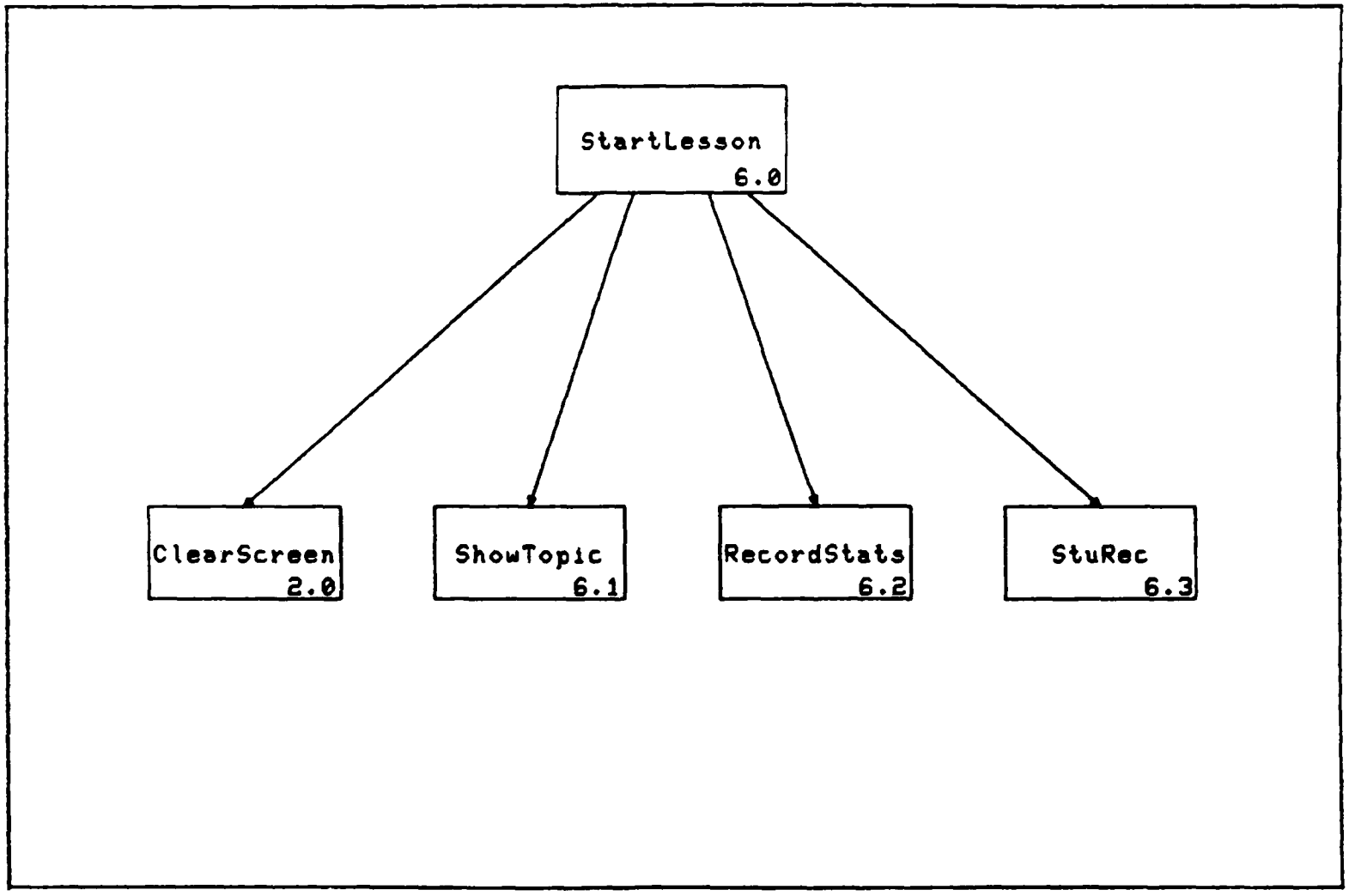


Figure 4.3 CAI - StartLesson

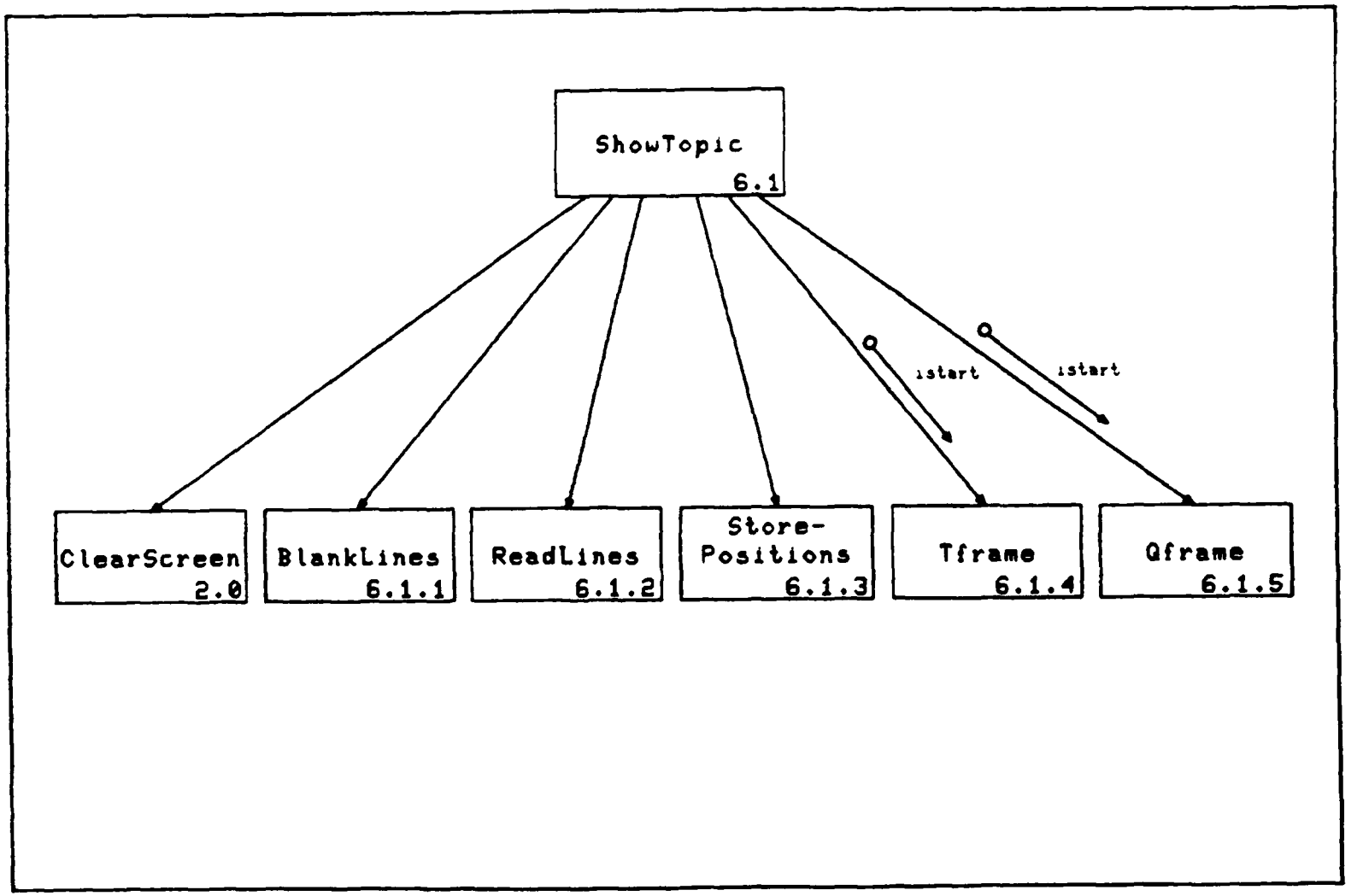


Figure 4.4 CAI - ShowTopic

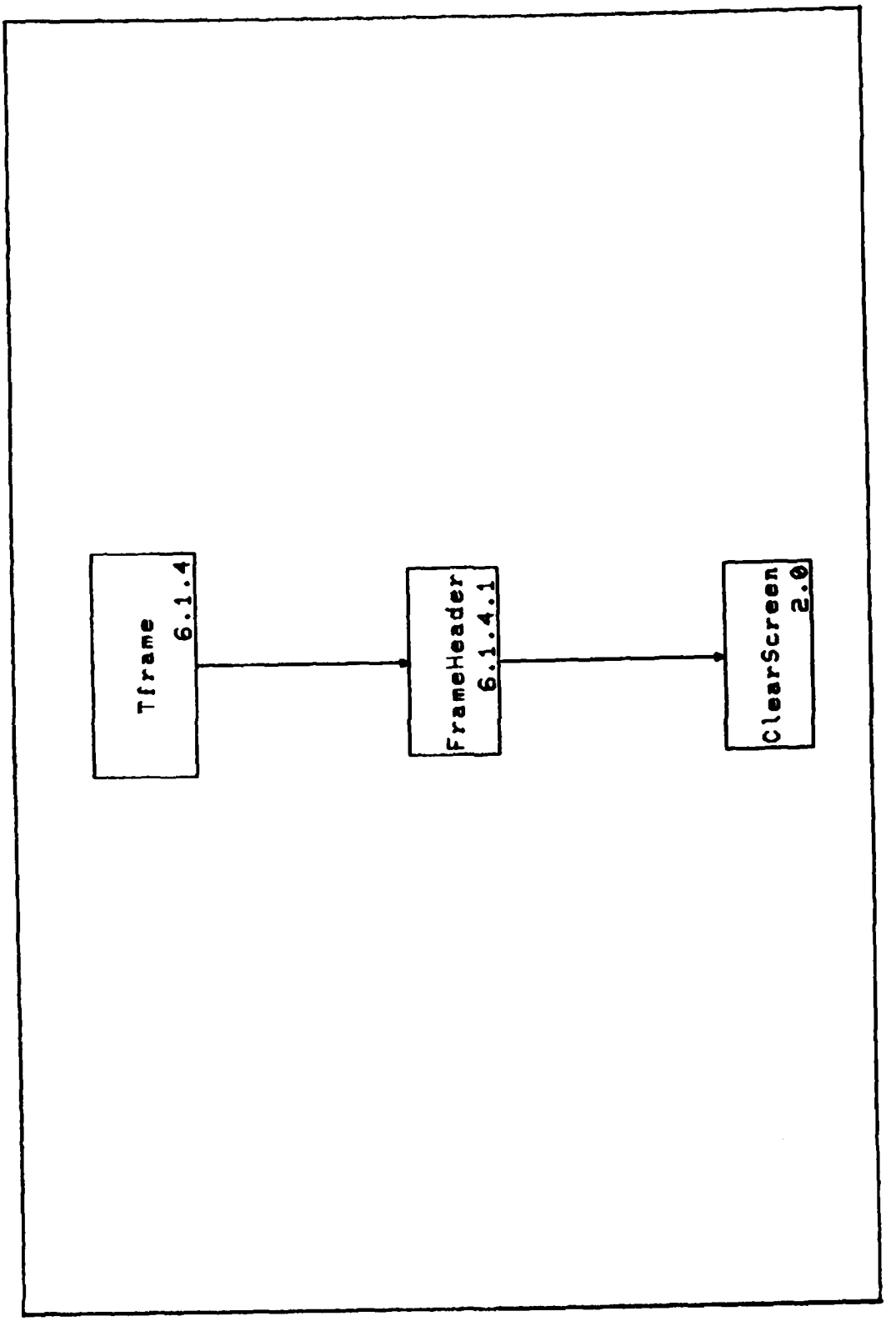


Figure 4.5 CAI - Tframe

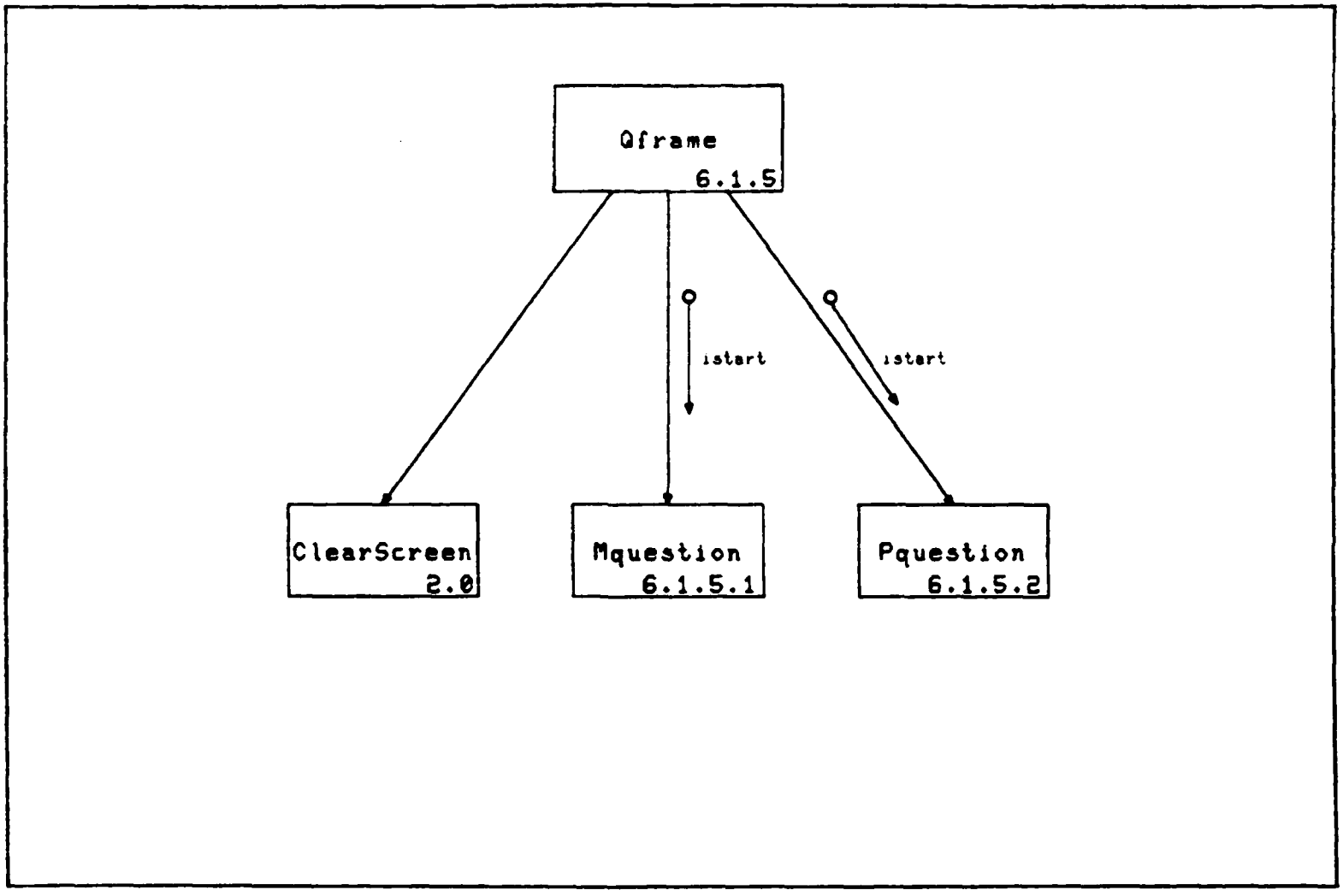


Figure 4.6 CAI - Qframe

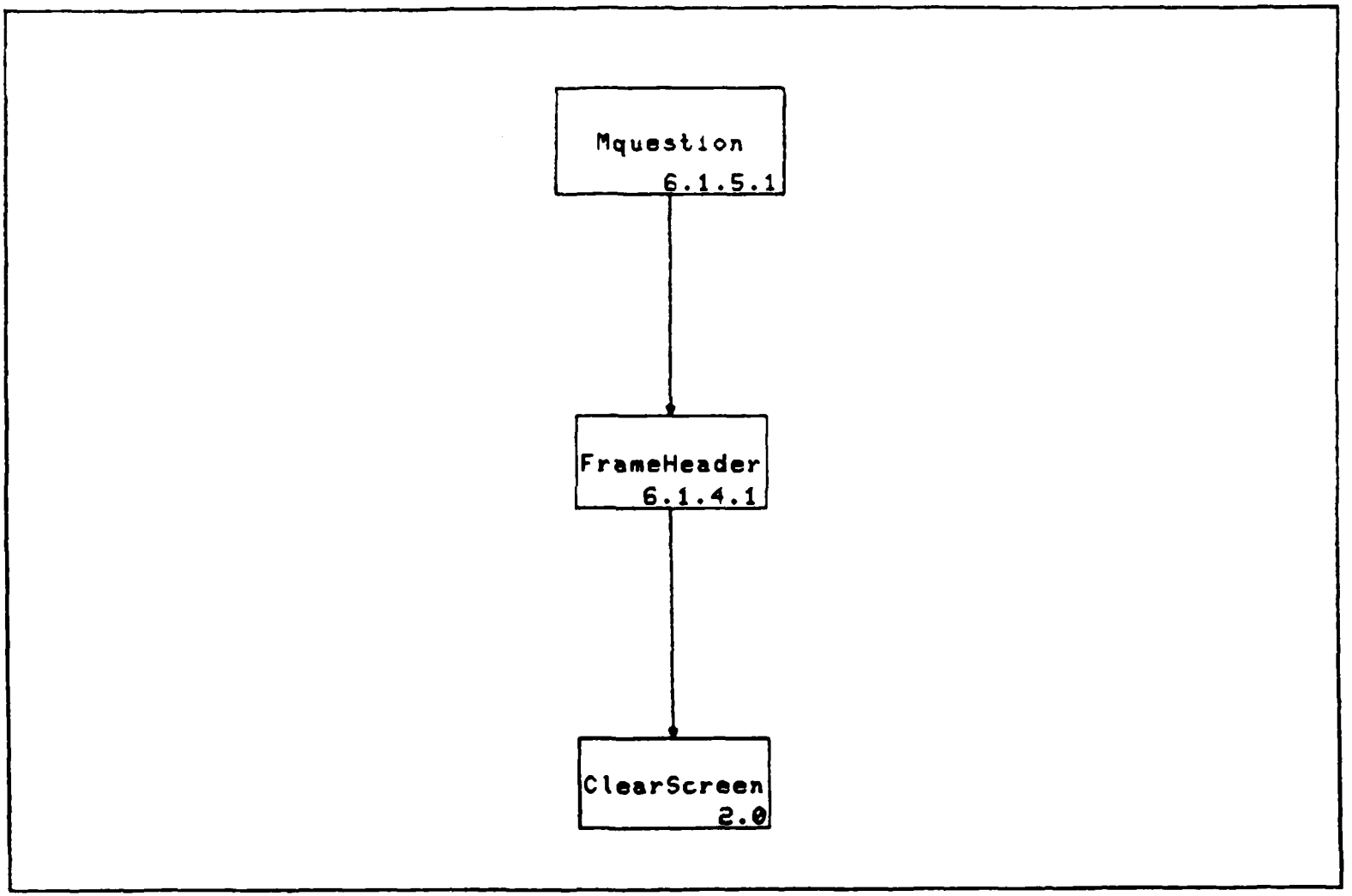


Figure 4.7 CAI - Mquestion

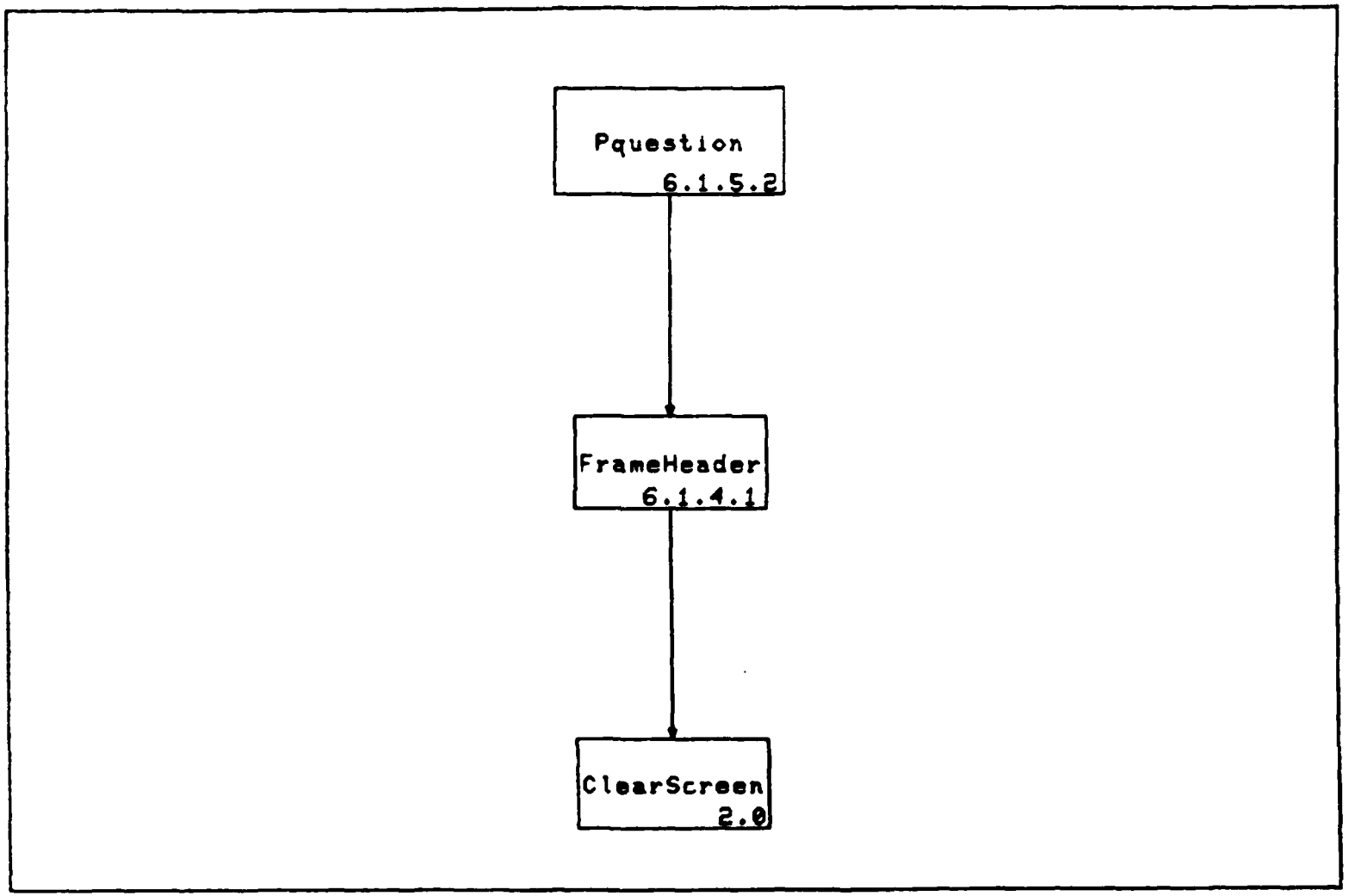


Figure 4.8 CAI - Pquestion

Status Program

Program Student_Status is the program that is used to present the current student status for all students recorded in file "STUDENT". The program is designed to accept and present any number of student records. This provides for the merging of several student files prior to running the program. There are two output formats for this program, "screen" and "hardcopy". The following is a breakdown and brief description of the program.

Structure Chart. The program is broken into a main program and five procedures, all of which are written in the Pascal programming language. A structure chart of this program is presented in Figure 4.9 of this chapter.

Flow Description. The flow of this program follows a strightforward path. The program begins by asking the user for the preferred method of report format, choices are either "screen" or "hardcopy". A header is then displayed and is followed by the student progress information. The structure of the report is in the format of "student identification number" followed by the word "passed" for every lesson that the student has successfully completed.

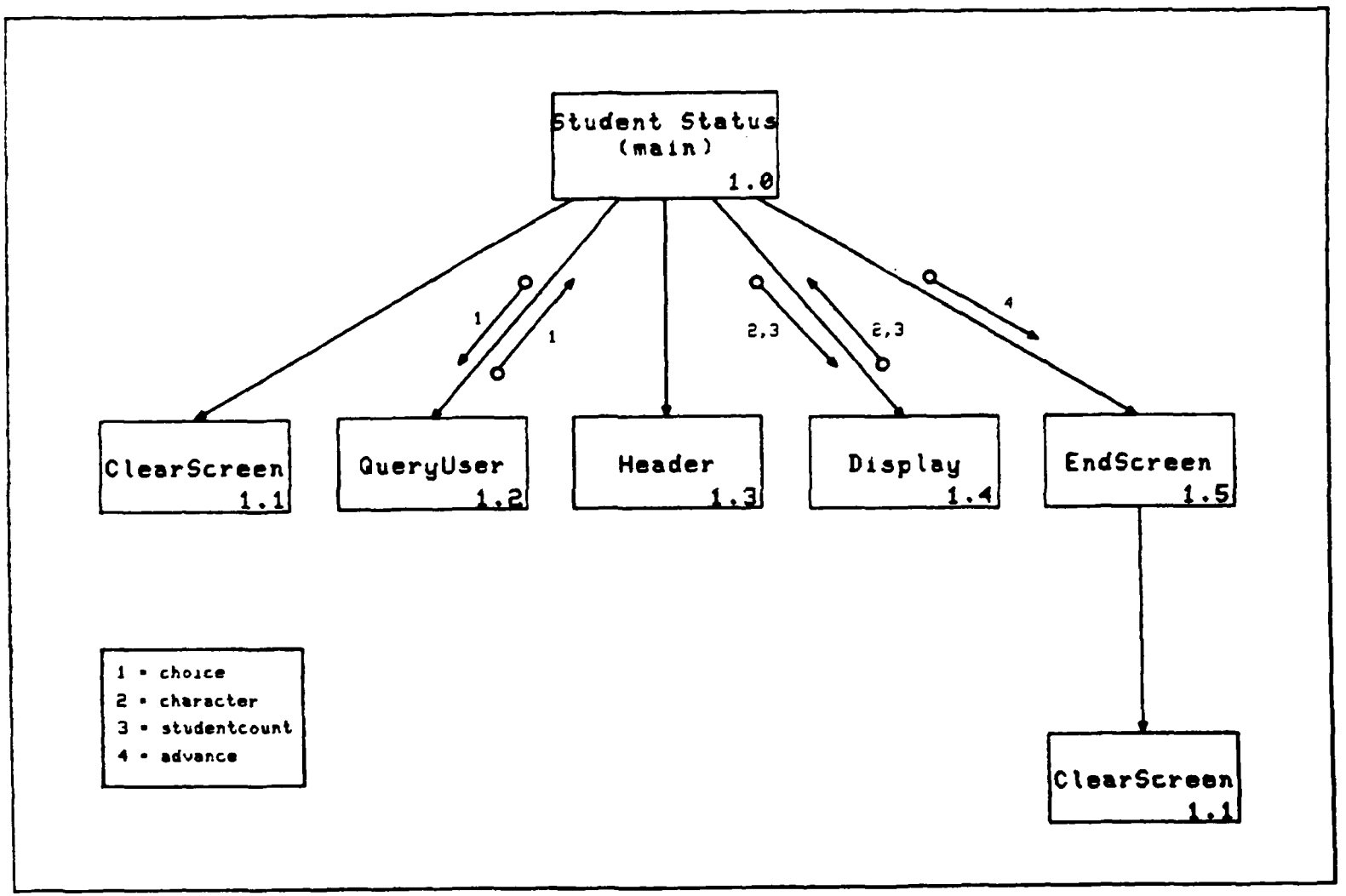


Figure 4.9 Student Status - Main

Statistics Program

Program CAI_Statistics is the program that is used to present the statistics collected on all questions asked during all course presentation sessions. The purpose of the program is to provide a means for the office of primary responsibility (OPR) at Keesler AFB to verify course content and effectiveness. The program is designed to accept and present statistics on as many as 150 different question frames. This restriction can be overcome by changing one line of source code (a constant value), if it becomes necessary. Several "STATS" files can be combined (and should be) before running this program. There are two output formats for this program, "screen" and "hardcopy". The following is a breakdown and brief description of the program.

Structure Charts. The program is broken into a main program and eight procedures, all of which are written in the Pascal programming language. Structure charts of this program are presented in Figures 4.10 thru 4.12 of this chapter.

Flow Description. The flow of this program follows a strightforward path. The program begins by asking the user for the preferred method of report format, choices are either "screen" or "hardcopy". A header is then displayed and is followed by internal reading and sorting routines. The output report is displayed in columns, giving all the needed statistics to the user. Items such as percent right and percent wrong help to validate questions.

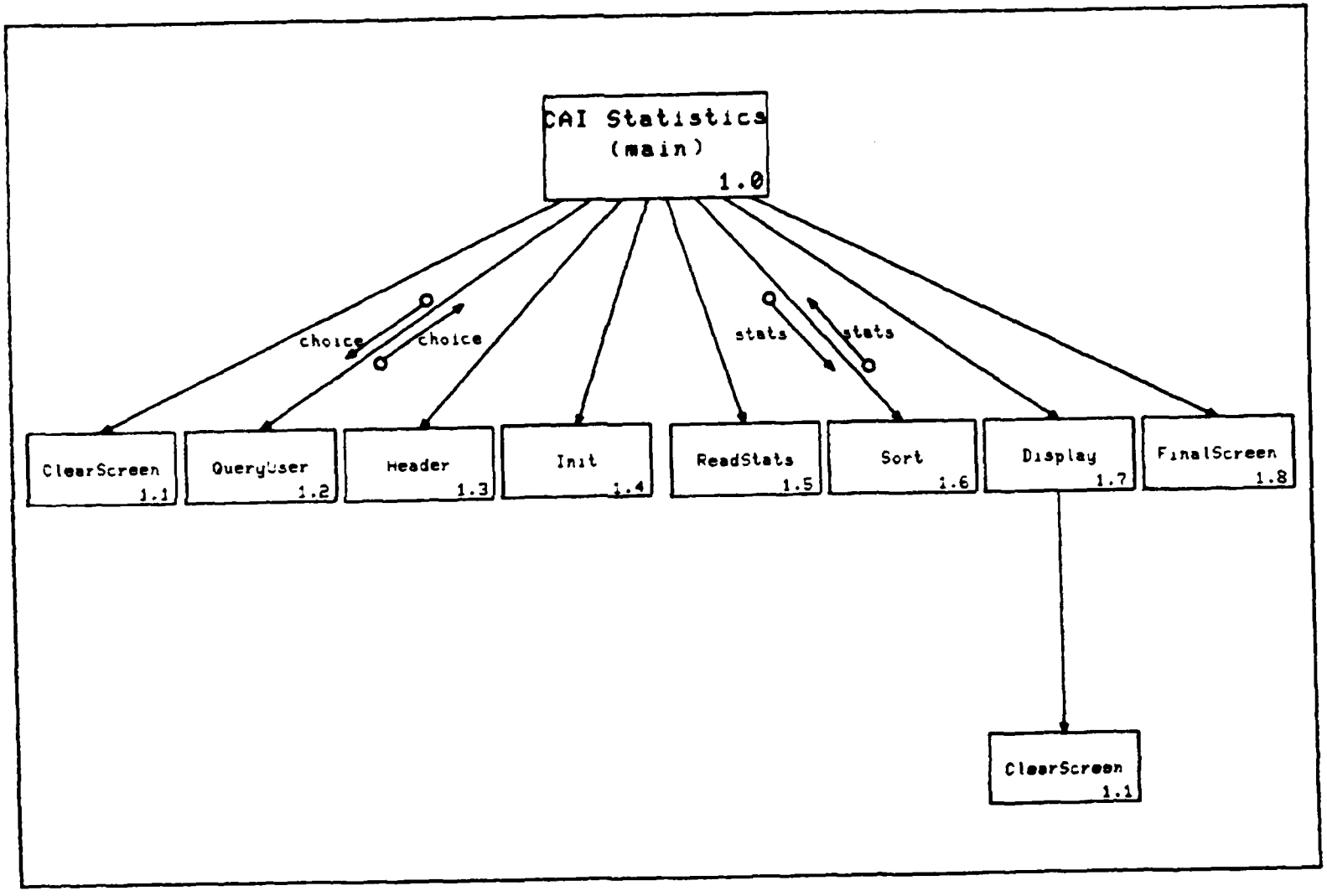


Figure 4.10 CAI Statistics - Main

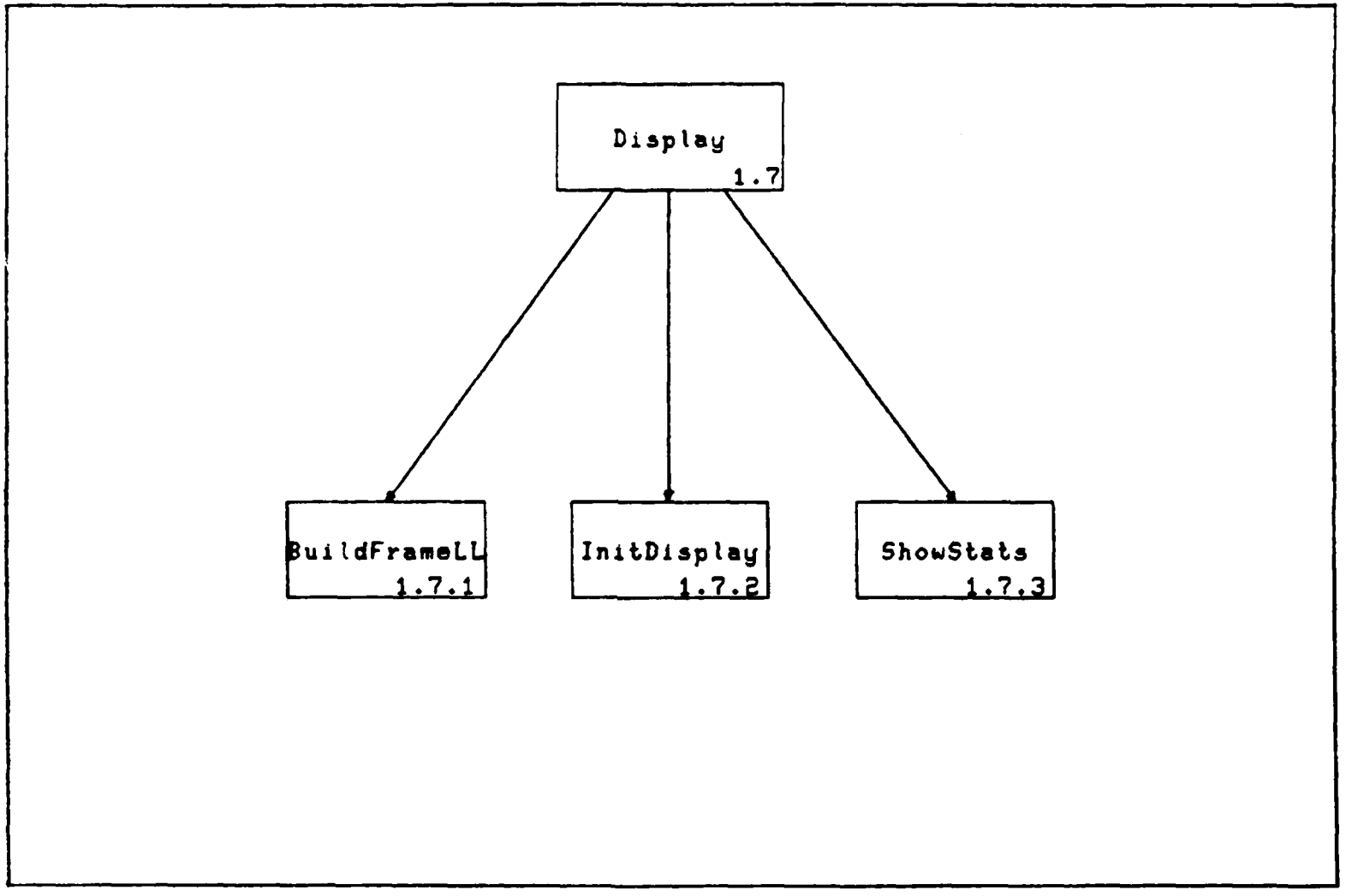


Figure 4.11 CAI Statistics - Display

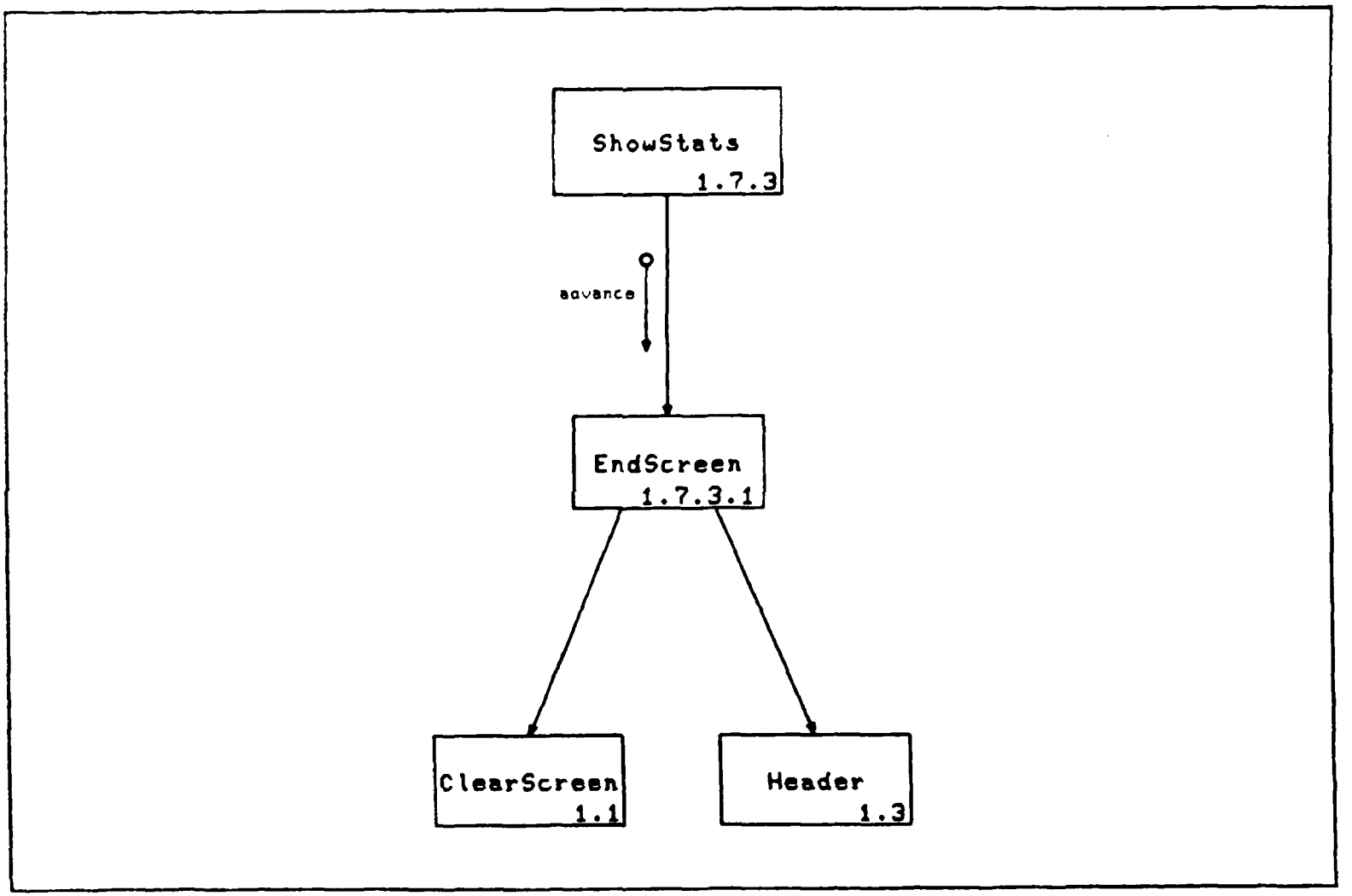


Figure 4.12 CAI Statistics - ShowStats

V. Conclusions and Recommendations

General Comments

The computer assisted instruction (CAI) package developed, tested, and implemented in this thesis effort presents an introduction to the "C" programming language. Although it does not get deep into fancy "C" language usage, it does serve its primary purpose of providing a strong base from which the student can build his/her "C" programming expertise. With a little initiative, the student will soon have the full power of the language at their disposal.

As was mentioned in chapter one, the primary goal of this study was to develop a course on the "C" programming language to be presented on the Zenith Z-100 microcomputer system. In order to achieve the stated goal a secondary goal had to be met, that of developing a software presentation system for the developed course material. This secondary goal provides the possibility of producing other courses for presentation on the Z-100 system.

Suggestions for Further Study

The existing presentation program is a good one as it stands, but certain enhancements would make it better. One such enhancement would be to add logic to allow for the asking of "fill in the blank" type questions. Another would be to allow the student to backup to a previously seen frame. One improvement in program control would be to read in the first frame of a topic, display it, and then read in

the rest of the topic while the student is reading the first frame. Currently, the student must wait nearly one minute before any topic material is displayed after they have chosen the topic from the topic menu.

Finally, the overall "C" course can be improved in several ways. Two of these are: provide for more branching to supplemental material and cover more of the capabilities of the "C" programming language. The course material and the programs used in conjunction with its use can be an effective means of getting introduced to the wonders of "C" programming.

Appendix A

Users Guide

Using Program "CAI"

Program CAI is the main program of this computer assisted instruction (CAI) package. The executable program is stored on "Disk 1" under the filename CAI.EXE. To start this program running, you need to boot the Zenith Z-100 microcomputer using the MS-DOS operating system. Remove the operating system disk from drive A, place "Disk 1" in drive A and "Disk 2" in drive B. Disk 2 contains the six lesson files of the C CAI course.

Once the disks are in place, type CAI in response to the A> prompt. The main CAI program will begin to execute and will prompt you for any further needed responses. One important item that deserves special mention is the student identification number that you will be prompted for during initial startup. This number is used to keep track of an individual's progress through the course. In order for it to be an effective feature of the package, the same sequence of characters must be entered each time you enter the CAI program.

Using Program "STUDENT STATUS"

Program Student_Status is designed for system training monitors. It is not for use by the students taking the course. This program will produce a report giving the current student status for each student recorded in file

"STUDENT" on "Disk 1". The executable program is stored on "Disk 1" under the filename STATUS.EXE. To start this program running, you need to boot the Zenith Z-100 microcomputer using the MS-DOS operating system. Replace the operating system disk in drive A with "Disk 1" of the CAI package. Once the disk is in place, type STATUS in response to the A> prompt. The Student_Status program will begin to execute and will prompt you for any further needed responses.

Using Program "CAI_STATISTICS"

Program CAI_Statistics is designed for the office of primary responsibility (OPR) at Keesler AFB. It is not for use by the students taking the course. This program will produce a report giving statistics on all the C CAI course questions recorded in file "STATS" on "Disk 1". The executable program is stored on "Disk 1" under the filename VALIDATE.EXE. To start this program running, you need to boot the Zenith Z-100 microcomputer using the MS-DOS operating system. Replace the operating system disk in drive A with "Disk 1" of the CAI package. Once the disk is in place, type VALIDATE in response to the A> prompt. The CAI_Statistics program will begin to execute and will prompt you for any further needed responses.

Appendix B

Program Listings

Program "CAI"

```
(**** THIS PROGRAM WAS WRITTEN IN PARTIAL FULFILLMENT OF A MASTERS THESIS ****)
(*****************************************************************************)
*   Date: 8/1/85                                                              *
*   Version: 1.0                                                              *
*                                                                             *
*   Title: Program CAI                                                        *
*   Filename: CAI.PAS                                                         *
*   Coordinator: Capt Frank W. DeMarco                                        *
*   Project: Masters Thesis                                                   *
*   Operating System: MS-DOS                                                  *
*   Language: Pascal                                                          *
*   Use: Compile and link with PASCAL.LIB using MS-Pascal compiler and linker.*
*   Contents: Program CAI - Main Driver.                                      *
*             Procedure ClearScreen - Clears Z-100 terminal screen.           *
*             Procedure RegStu - Registers a first time student.              *
*             Procedure Query - Reads in "STUDENT" file, prompts student for  *
*                               student identification number, and checks the *
*                               ID number against current student list.       *
*             Procedure StartEnd - Reads and displays files "INTRO" at start  *
*                                  of program and "EXIT" at end of program.   *
*             Procedure Select - Reads and displays file "MENU", prompts the  *
*                                student for choice of lesson to be shown.    *
*             Procedure ShowTopic - Driver of procedures that display topic   *
*                                   material.                                 *
*             Procedure BlankLines - Initializes area where topic material is *
*                                    stored to blanks.                        *
*             Procedure Readlines - Reads in topic that the student chose to  *
*                                   view.                                     *
*             Procedure StorePositions - Builds an array of line positions    *
*                                        where frames begin within the topic. *
*             Procedure FrameHeader - Displays a frame header for a frame.    *
*             Procedure Tframe - Displays a text type frame.                  *
*             Procedure Qframe - Driver for the procedures that display and   *
*                                handle question type frames.                 *
*             Procedure Mquestion - Displays and handles multiple choice type *
*                                   question frames.                          *
*             Procedure Pquestion - Displays and handles pick type question   *
*                                   frames (true/false and yes/no).           *
*             Procedure RecordStats - Reads file "STATS" and adds statistical *
*                                     data from current session.              *
*             Procedure StuRec - Writes updated student course progress data  *
*                                to file "STUDENT".                           *
*             Procedure StartLesson - Displays topic choices for a lesson,    *
*                                     prompts student for choice of topic to  *
*                                     be shown. Driver of procedures that     *
*                                     display lesson material and update      *
```

```
*                                        statistical & student progress files.   *
*                                                                                *
*   Function: The purpose of this program is to present material on the "C"      *
*             programming language.  It is intended for use by the 3300 Tech-    *
*             nical Training  Wing in support of its mission.  The office of     *
*             primary responsibility for this course is the CAI Plans Branch     *
*             (3300 TCHTW/TTGXZ) at Keesler AFB, MS  39534                       *
*                                                                                *
**********************************************************************************)

(**********************************************************************************
*   Date: 8/1/85                                                                 *
*   Version: 1.0                                                                 *
*                                                                                *
*   Name: program CAI                                                            *
*   Module number: 1.0                                                           *
*   Description: Main driver of program                                          *
*   Passed Variables: None                                                       *
*   Returns: None                                                                *
*   Global Variables Used: studentcount, choice                                  *
*   Global Variables Changed: None                                               *
*   Files Read: None                                                             *
*   Files Written: None                                                          *
*   Modules Called: ClearScreen, StartEnd, Query, Select, StartLesson            *
*   Calling modules: None                                                        *
*                                                                                *
*   Author: Capt Frank W. DeMarco                                                *
*   History:                                                                     *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                           *
**********************************************************************************)

program CAI (input,output);

const
 MAXSTUDENTS = 20;
 MAXLESSONS = 6;
 MAXTOPICS = 5;
 VLESSON = '6';
 VTOPIC = '5';
 ALINEP1 = '*******************************************';
 ALINEP2 = '*******************************************';
 ABLANKS = '*                                         ';
 BLANKSA = '                                        *';

type
 iofile = TEXT;
 roll = record
         studentnumber : packed array [1..11] of char;
         studentname : packed array [1..29] of char;
         lessons : packed array [1..MAXLESSONS] of char;
         topics : array [1..MAXLESSONS, 1..MAXTOPICS] of char;
        end;
 roster = array [1..MAXSTUDENTS] of roll;
```

```
 lstat = array [1..MAXLESSONS] of char;
 displayln = packed array [1..80] of char;
 lessonlines = array [1..500, 1..80] of char;
 menulines = array [1..22, 1..80] of char;
 tstat = array [1..MAXTOPICS] of char;


var
 iomessage, student, statfile, menu, lesson, temp1, temp2 : iofile;
 advance, linecount, studentcount : integer;
 choice, lchoice : char;
 npupil : roll;
 rpupil : roster;
 lessonstat : lstat;
 println : displayln;
 lessonln : lessonlines;
 menuln : menulines;
 topicstat : tstat;

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure ClearScreen                                              *
*   Module number: 2.0                                                       *
*   Description: Clears Z-100 terminal screen and sets "no-wrap" on EOL.     *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: None                                              *
*   Global Variables Changed: None                                           *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: None                                                     *
*   Calling modules: program CAI, StartEnd, Query, Select, RegStu,           *
*                    StartLesson, ShowTopic, Qframe, FrameHeader             *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure ClearScreen;

begin  {* Procedure ClearScreen *}

 write (chr(27),'H',chr(27),'J',chr(27),'w')

end;   {* Procedure ClearScreen *}

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
```

```
*   Name: procedure RegStu                                                    *
*   Module number: 4.1                                                        *
*   Description: Registers a first time student.                              *
*   Passed Variables: None                                                    *
*   Returns: None                                                             *
*   Global Variables Used: npupil, studentcount                               *
*   Global Variables Changed: npupil, studentcount                            *
*   Files Read: None                                                          *
*   Files Written: None                                                       *
*   Modules Called: ClearScreen                                               *
*   Calling modules: Query                                                    *
*                                                                             *
*   Author: Capt Frank W. DeMarco                                             *
*   History:                                                                  *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                        *
*****************************************************************************)

procedure RegStu;

var
 i, j : integer;

begin  (* Procedure RegStu *)

 for j := 1 to 11 do
   npupil.studentnumber[j] := ' ';
 for j := 1 to 28 do
   npupil.studentname[j] := ' ';
 for j := 1 to MAXLESSONS do
   npupil.lessons[j] := ' ';
 for i := 1 to MAXLESSONS do
   begin
    for j := 1 to MAXTOPICS do
      npupil.topics[i,j] := ' '
   end;

 writeln;
 writeln('Since this is your first time into this course, I have a few ');
 writeln('administrative matters to take care of.');
 writeln;
 writeln('Please enter your first name: ');
 write('(Max. of 10 characters) >>>>> ');

 i := 1;
 while not (eoln) and (i < 11) do
   begin
    read (npupil.studentname[i]);
    i := i + 1
   end;
 if (eoln) and (i < 11) then
   begin
    for i := i to 10 do
      npupil.studentname[i] := '*';
```

```
    readln
   end
 else
   readln;

 writeln;
 writeln;

 writeln('Please enter your middle initial: ');
 write('(Max. of 1 character) >>>>>>>>>>> ');

 i := 11;
 while not (eoln) and (i < 12) do
   begin
    read (npupil.studentname[i]);
    i := i + 1
   end;
 if (npupil.studentname[11] in ['a'..'z','A'..'Z']) then
   begin
    npupil.studentname[12] := '.';
    readln
   end
 else
   begin
    npupil.studentname[11] := '*';
    npupil.studentname[12] := '*';
    readln
   end;

 writeln;
 writeln;

 writeln('Please enter your last name: ');
 write('(Max. of 16 characters) >>>> ');

 i := 13;
 while not (eoln) and (i < 29) do
   begin
    read (npupil.studentname[i]);
    i := i + 1
   end;
 if (eoln) and (i < 29) then
   begin
    for i := i to 28 do
      npupil.studentname[i] := '*';
      readln
   end
 else
   readln;

 writeln;
 writeln;
```

```
    writeln('Now for the most important part.');
    writeln('Please enter your unique, personal student identification number: ');
    write('(Max. of 11 characters) >>>>> ');

    i := 1;
    while not (eoln) and (i < 12) do
      begin
       read (npupil.studentnumber[i]);
       i := i + 1
      end;
    if (eoln) and (i < 12) then
      begin
       for i := i to 11 do
         npupil.studentnumber[i] := '*';
       readln
      end
    else
      readln;

    for i := 1 to MAXLESSONS do
      begin
       npupil.lessons[i] := '-';
       for j := 1 to MAXTOPICS do
         npupil.topics[i,j] := '-';
      end;

    studentcount := studentcount + 1

  end;   (* Procedure RegStu *)

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure Query                                                    *
*   Module number: 4.0                                                       *
*   Description: Reads in "STUDENT" file, prompts student for student identi- *
*                fication number, and checks the ID number against current   *
*                student list.                                               *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: rpupil, studentcount, npupil                      *
*   Global Variables Changed: rpupil, studentcount, npupil                   *
*   Files Read: student                                                      *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen, RegStu                                      *
*   Calling modules: program CAI                                             *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}
```

```
procedure Query;

var
 i, ii, j : integer;

 qfound : boolean;
 character : char;

begin  (* Procedure Query *)

 assign (student,'student');
 reset (student);
 character := ' ';
 if not (eof(student)) then
   read (student,character);

 for i := 1 to MAXSTUDENTS do
   begin
    for j := 1 to 11 do
      rpupil[i].studentnumber[j] := ' ';
    for j := 1 to 28 do
      rpupil[i].studentname[j] := ' ';
    for j := 1 to MAXLESSONS do
      rpupil[i].lessons[j] := ' ';
    for ii := 1 to MAXLESSONS do
      begin
       for j := 1 to MAXTOPICS do
         rpupil[i].topics[ii,j] := ' '
      end;
   end;

 i := 1;
 studentcount := 0;
 while (character = '>') and not (eof(student)) do
   begin
    studentcount := studentcount + 1;
    while not (eoln(student)) do
      begin
       for j := 1 to 11 do
         read (student,rpupil[i].studentnumber[j]);
       for j := 1 to 28 do
         read (student,rpupil[i].studentname[j]);
       for j := 1 to MAXLESSONS do
         read (student,rpupil[i].lessons[j]);
       for ii := 1 to MAXLESSONS do
         begin
          for j := 1 to MAXTOPICS do
            read (student,rpupil[i].topics[ii,j])
         end;
       i := i + 1;
      end;
    if not (eof(student)) then
      readln (student);
```

```
    if not (eof(student)) then
      read (student,character);
  end;

ClearScreen;

write('Please enter your student identification number: ');
write('(Max. of 11 characters) >>>>> ');

i := 1;
while not (eoln) and (i < 12) do
  begin
   read (npupil.studentnumber[i]);
   i := i + 1
  end;
if (eoln) and (i < 12) then
  begin
   for i := i to 11 do
     npupil.studentnumber[i] := '*'
  end;
readln;

i := 1;
qfound := false;
while (i < 21) do
  begin
   if (npupil.studentnumber = rpupil[i].studentnumber) then
     begin
      qfound := true;
      npupil.studentname := rpupil[i].studentname;
      npupil.lessons := rpupil[i].lessons;
      for ii := 1 to MAXLESSONS do
        begin
         for j := 1 to MAXTOPICS do
           npupil.topics[ii,j] := rpupil[i].topics[ii,j]
        end;
     end;
   i := i + 1
  end;

if not (qfound) and (studentcount < MAXSTUDENTS) then
  begin
   ClearScreen;
   writeln ('NO MATCH FOUND');
   RegStu;
   ClearScreen
  end
else
  if not (qfound) and (studentcount >= MAXSTUDENTS) then
    begin
     ClearScreen;
     studentcount := studentcount + 1;
     writeln('Sorry, but my class roster shows a "Full" class.');
```

```
        writeln('Please see your training monitor for a new student disk.');
        writeln;
        writeln('END OF PROGRAM')
       end;

 close (student)

end;   {* Procedure Query *}

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure StartEnd                                                 *
*   Module number: 3.0                                                       *
*   Description: Reads and displays files "INTRO" at start of program and    *
*                "EXIT" at end of program.                                   *
*   Passed Variables: code                                                   *
*   Returns: None                                                            *
*   Global Variables Used: println, linecount, advance                       *
*   Global Variables Changed: println, linecount, advance                    *
*   Files Read: intro, exit                                                  *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen                                              *
*   Calling modules: program CAI                                             *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure StartEnd(code : char);

var
 character : char;
 i : integer;

begin  {* Procedure StartEnd *}

 case code of
  'S' : assign (iomessage,'intro');
  'E' : assign (iomessage,'exit')
 end;

 reset (iomessage);
 read (iomessage,character);
 linecount := 0;

 repeat

 while (character = '#') and not (eof(iomessage)) do
   begin
    for i := 1 to 80 do
```

```
        println[i] := ' ';
      readln (iomessage,println);
      linecount := linecount + 1;
      writeln (println);
      if not (eof(iomessage)) then
        read (iomessage,character)
    end;

  if (character = 'f') then
    begin
      advance := 23 - linecount;
      linecount := 0;
      for i := 1 to advance do
        writeln;
      for i := 1 to 27 do
        write (' ');
      write ('Press  RETURN  to continue.');
      readln;
      if not (eof(iomessage)) then
        begin
          readln (iomessage);
          if not (eof(iomessage)) then
            read (iomessage,character)
        end;
      ClearScreen
    end;
  until (eof(iomessage));

  close (iomessage)

end;  (* Procedure StartEnd *)

(*****************************************************************************
*   Date: 9/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure Select                                                   *
*   Module number: 5.0                                                       *
*   Description: Reads and displays file "MENU", prompts the student for     *
*                choice of lesson to be shown.                               *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: lessonstat, println, choice                       *
*   Global Variables Changed: lessonstat, println, choice                    *
*   Files Read: menu                                                         *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen                                              *
*   Calling modules: program CAI                                             *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 9/1/85 - input original code                       *
*****************************************************************************)
```

```
procedure Select;

var
 character : char;
 i, j : integer;

begin  (* Procedure Select *)

 assign (menu,'menu');

 for i := 1 to MAXLESSONS do
   lessonstat[i] := npupil.lessons[i];

 repeat

 reset (menu);
 read (menu,character);

 j := 0;
 while (character in ['*','@']) and not (eof(menu)) do
   begin
    readln (menu,println);

    if (character = '*') then
      begin
       write ('*');
       for i := 2 to 78 do
         write (println[i]);
       writeln (println[79])
      end
    else
      begin
       j := j + 1;
       write ('*');
       for i := 2 to 8 do
         write (println[i]);
       write (lessonstat[j]);
       for i := 10 to 78 do
         write (println[i]);
       writeln (println[79])
      end;

    if not (eof(menu)) then
      read (menu,character)
   end;

 writeln;
 write ('ENTER THE NUMBER OF YOUR CHOICE OR "X" TO EXIT THE CAI PROGRAM: ');
 readln (choice);
 if (choice in ['1'..VLESSON,'x','X']) then
   ClearScreen
 else
```

```
    begin
     ClearScreen;
     writeln ('Sorry, ',choice,' is not a valid response. Please try again.')
    end;

 until (choice in ['1'..VLESSON,'x','X']);

 if (choice in ['1'..VLESSON]) then
   writeln ('You have chosen lesson number ',choice,'. Thank you.')
 else
   writeln ('OK, I will now return you to the operating system.');

 close (menu)

end;   {* Procedure Select *}

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure ShowTopic                                                *
*   Module number: 6.1                                                       *
*   Description: Driver of procedures that display topic material.           *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: lessonln, npupil, topicstat                       *
*   Global Variables Changed: npupil, topicstat                              *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen, BlankLines, ReadLines, StorePositions,      *
*                   Tframe, Qframe                                           *
*   Calling modules: StartLesson                                             *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure ShowTopic;

const
 MINSCORE = 70.0;

type
 position = record
             framenum : integer;
             ivalue : integer;
            end;
 topictitle = packed array [1..30] of char;

var
 lplace : array [1..50] of position;
 tname : topictitle;
```

```
  i, j, k, istart, nextframe, frame : integer;
  numasked, numright, score : real;
  sfound, test : boolean;
  ftype : char;

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure BlankLines                                               *
*   Module number: 6.1.1                                                     *
*   Description: Initializes area where topic material is stored to blanks.  *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: lessonln, tname, lplace                           *
*   Global Variables Changed: lessonln, tname, lplace                        *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: None                                                     *
*   Calling modules: ShowTopic                                               *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure BlankLines;

var indexi, indexj : integer;

begin  (* Procedure BlankLines *)

 for indexi := 1 to 500 do
   begin
    for indexj := 1 to 80 do
      lessonln[indexi,indexj] := ' '
   end;

 for indexi := 1 to 30 do
   tname[indexi] := ' ';

 for indexi := 1 to 50 do
   begin
    lplace[indexi].framenum := 0;
    lplace[indexi].ivalue := 0;
   end;

end;   (* Procedure BlankLines *)

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
```

```
*   Name: procedure ReadLines                                                  *
*   Module number: 6.1.2                                                       *
*   Description: Reads in topic that the student chose to view.                *
*   Passed Variables: None                                                     *
*   Returns: None                                                              *
*   Global Variables Used: lessonln, lchoice, tname                            *
*   Global Variables Changed: lessonln, tname                                  *
*   Files Read: lesson                                                         *
*   Files Written: None                                                        *
*   Modules Called: None                                                       *
*   Calling modules: ShowTopic                                                 *
*                                                                              *
*   Author: Capt Frank W. DeMarco                                              *
*   History:                                                                   *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                         *
*******************************************************************************)

procedure ReadLines;

var
 rfound : boolean;
 jvalue , ivalue : integer;

begin  (* Procedure ReadLines *)

 writeln;
 writeln ('One moment please...');

 rfound := false;
 reset (lesson);

 repeat
  read (lesson,lessonln[1,1]);
  if (lessonln[1,1] = lchoice) then
    rfound := true
  else
    readln(lesson);
 until (rfound);

 j := 2;
 while not (eoln(lesson)) do
   begin
    read (lesson,lessonln[1,j]);
    j := j + 1
   end;

 readln (lesson);
 i := 2;
 read (lesson,lessonln[i,1]);

 j := 2;
```

```
 while (lessonIn[i,1] = lchoice) and not (eof(lesson)) do
   begin
    while not (eoln(lesson)) do
      begin
       read (lesson,lessonIn[i,j]);
       j := j + 1
      end;
    readln (lesson);
    i := i + 1;
    j := 1;
    if not (eof(lesson)) then
       read (lesson,lessonIn[i,j]);
    j := j + 1
   end;

 ivalue := 1;
 for jvalue := 16 to 45 do
   begin
    tname[ivalue] := lessonIn[1,jvalue];
    ivalue := ivalue + 1;
   end;

end;   {* Procedure ReadLines *}

{*****************************************************************************
*   Date: 8/1/95                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure StorePositions                                           *
*   Module number: 6.1.3                                                     *
*   Description: Builds an array of line positions where frames begin within *
*                the topic.                                                  *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: lessonIn, i, j, k, lplace, lchoice                *
*   Global Variables Changed: i, j, k, lplace                                *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: None                                                     *
*   Calling modules: ShowTopic                                               *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/95 - input original code                       *
*****************************************************************************}

procedure StorePositions;

var
 number, jval : integer;

begin  {* Procedure StorePositions *}
```

```
    i := 1;
    j := 2;
    k := 0;

    repeat
     if (lessonln[i,j] = '1') then
       begin
        k := k + 1;
        fnumber := 0;
        for jval := 9 to 11 do
          fnumber := (10 * fnumber) + ((ord(lessonln[i,jval])) - ord('0'));
        lplace[k].framenum := fnumber;
        lplace[k].ivalue := i;
        i := i + 1
       end
     else
       i := i + 1;
    until (lessonln[i,1] <> lchoice);

    k := k + 1;                 (* This marks the end *)
    lplace[k].framenum := -1;   (* of the array *)

  end;   (* Procedure StorePositions *)

  (*****************************************************************************
  *   Date: 8/1/85                                                            *
  *   Version: 1.0                                                            *
  *                                                                           *
  *   Name: procedure FrameHeader                                             *
  *   Module number: 7.0                                                      *
  *   Description: Displays a frame header for a frame.                       *
  *   Passed Variables: None                                                  *
  *   Returns: None                                                           *
  *   Global Variables Used: None                                             *
  *   Global Variables Changed: None                                          *
  *   Files Read: None                                                        *
  *   Files Written: None                                                     *
  *   Modules Called: ClearScreen                                             *
  *   Calling modules: Tframe, Mquestion, Pquestion                           *
  *                                                                           *
  *   Author: Capt Frank W. DeMarco                                           *
  *   History:                                                                *
  *    1.0 Frank W. DeMarco 8/1/85 - input original code                      *
  *****************************************************************************)

  procedure FrameHeader;

  begin  (* Procedure FrameHeader *)

   ClearScreen;

   writeln (ALINEP1,ALINEP2);
```

```
 writeln ('* Lesson #',choice,' * Topic #',lchoice,' * Title: ',tname,
          '   * Frame: ',frame:3,' *');
 writeln (ALINEP1,ALINEP2)

end;   (* Procedure FrameHeader *)

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure Tframe                                                   *
*   Module number: 6.1.4                                                     *
*   Description: Displays a text type frame.                                 *
*   Passed Variables: istart                                                 *
*   Returns: None                                                            *
*   Global Variables Used: advance, linecount, lessonln, nextframe           *
*   Global Variables Changed: advance, linecount, nextframe                  *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: FrameHeader                                              *
*   Calling modules: ShowTopic                                               *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure Tframe(istart : integer);

var
 jnum : integer;

begin  (* Procedure Tframe *)

 advance := 0;
 linecount := 0;
 istart := istart + 1;

 FrameHeader;
 writeln (ABLANKS,BLANKSA);

 repeat
  while (lessonln[istart,2] = '2') and (linecount < 17) do
    begin
     write ('* ');
     for jnum := 3 to 78 do
       write (lessonln[istart,jnum]);
     writeln (' *');
     istart := istart + 1;
     linecount := linecount + 1;
    end;
  writeln (ABLANKS,BLANKSA);
  advance := 22 - (linecount + 5);
```

```
    for jnum := 1 to (advance - 1) do
      writeln (ABLANKS,BLANKSA);
    writeln (ALINEP1,ALINEP2);
    for jnum := 1 to 27 do
      write (' ');
    write ('Press  RETURN  to continue.');
    readln;
    linecount := 0;
    if (lessonln[istart,2] = '2') then
      begin
       FrameHeader;
       writeln (ABLANKS,BLANKSA)
      end;
  until (lessonln[istart,2] = '3');

  if (lessonln[istart,2] = '3') then
    begin
      if (lessonln[istart,3] = 'B') then
        begin
         nextframe := 0;
         for jnum := 5 to 7 do
           nextframe := (10 * nextframe) +
                        ((ord(lessonln[istart,jnum])) - ord('0'))
        end
      else
        nextframe := -1;
    end;

end;   (* Procedure Tframe *)

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure Qframe                                                   *
*   Module number: 6.1.5                                                     *
*   Description: Driver for the procedures that display and handle question  *
*                type frames.                                                *
*   Passed Variables: istart                                                 *
*   Returns: None                                                            *
*   Global Variables Used: lessonln                                          *
*   Global Variables Changed: None                                           *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen, Mquestion, Pquestion                        *
*   Calling modules: ShowTopic                                               *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure Qframe(istart : integer);
```

```
var
 qtype : char;
 ivalq : integer;

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure Mquestion                                                *
*   Module number: 6.1.5.1                                                   *
*   Description: Displays and handles multiple choice type question frames.  *
*   Passed Variables: istart                                                 *
*   Returns: None                                                            *
*   Global Variables Used: lessonln, test, choice, lchoice, frame, numright, *
*                          nextframe                                         *
*   Global Variables Changed: numright, nextframe                            *
*   Files Read: None                                                         *
*   Files Written: temp1                                                     *
*   Modules Called: FrameHeader                                              *
*   Calling modules: Qframe                                                  *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure Mquestion(istart : integer);

var
 jnum : integer;
 response, correct, groupnum : char;
 mfound : boolean;

begin  (* Procedure Mquestion *)

 istart := istart + 1;

 FrameHeader;

 writeln;
 writeln;

 while (lessonln[istart,2] = '2') do
   begin
    for jnum := 3 to 80 do
      write (lessonln[istart,jnum]);
    writeln;
    istart := istart + 1
   end;

 writeln;

 while (lessonln[istart,2] = '3') do
```

```
  begin
   if (lessonIn[istart,4] = '+') then
      correct := lessonIn[istart,3];
   write ('  ',lessonIn[istart,3],'  ');
   for jnum := 6 to 80 do
     write (lessonIn[istart,jnum]);
   writeln;
   istart := istart + 1
  end;

repeat
 writeln;
 write ('  Enter your choice here ==> ');
 readln (response);
 if (response in ['A'..'E','a'..'e']) then
   writeln
 else
   writeln ('  Sorry, that is not a valid response. Please try again.');
until (response in ['A'..'E','a'..'e']);

case response of
 'a','A' : response := 'A';
 'b','B' : response := 'B';
 'c','C' : response := 'C';
 'd','D' : response := 'D';
 'e','E' : response := 'E'
end;

writeln (temp1,choice,lchoice,frame:3,correct,response);

if (response = correct) then
  begin
   if (test) then
     numright := numright + 1.0;
   groupnum := '4'
  end
else
  groupnum := '5';

mfound := false;
repeat
 if (lessonIn[istart,2] = groupnum) then
   mfound := true
 else
   istart := istart + 1;
until (mfound);

if (groupnum = '4') then    (* Start Group '4' Logic *)
  begin
   while (lessonIn[istart,4] <> 'B') or (lessonIn[istart,5] <> ':') do
     begin
      for jnum := 4 to 80 do
        write (lessonIn[istart,jnum]);
```

```
          writeln;
          istart := istart + 1
        end;
      if (lessonln[istart,4] = 'B') and (lessonln[istart,5] = ':') then
        begin
         nextframe := 0;
         for jnum := 6 to 8 do
           nextframe := (10 * nextframe) +
                        ((ord(lessonln[istart,jnum])) - ord('0'))
        end
      else
        nextframe := -1
    end;                          (* End Group '4' Logic *)

  if (groupnum = '5') then     (* Start Group '5' Logic *)
    begin
     if (lessonln[istart,3] = response) and
        (lessonln[istart,4] = ' ') then
       begin
        while (lessonln[istart,4] <> 'B') or
              (lessonln[istart,5] <> ':') do
          begin
           for jnum := 5 to 80 do
             write (lessonln[istart,jnum]);
           writeln;
           istart := istart + 1
          end;
       end
      else
        begin
         mfound := false;
         jnum := 3;
         repeat
          while (lessonln[istart,jnum] <> ' ') and not (mfound) do
            begin
             if (lessonln[istart,jnum] = response) then
               mfound := true;
             jnum := jnum + 1
            end;
          if not (mfound) then
            begin
             istart := istart + 1;
             jnum := 3
            end
          else
            begin
             while (lessonln[istart,jnum] <> ' ') do
               jnum := jnum + 1
            end;
         until (mfound) or (lessonln[istart,2] <> '5');
         if (mfound) then
           begin
```

```
            while (lessonln[istart,4] <> 'B') or
                  (lessonln[istart,5] <> ':') do
              begin
               for jnum := jnum to 80 do
                 write (lessonln[istart,jnum]);
               writeln;
               jnum := 4;
               istart := istart + 1
              end;
            if (lessonln[istart,4] = 'B') and (lessonln[istart,5] = ':') then
              begin
               nextframe := 0;
               for jnum := 6 to 9 do
                 nextframe := (10 * nextframe) +
                              ((ord(lessonln[istart,jnum])) - ord('0'))
              end
            else
              nextframe := -1
           end
         else
           writeln ('SOMETHING IS AWRY!  LET''S TRY THAT AGAIN.')
       end;
    end;                          (* End Group '5' Logic *)

end;    (* Procedure Mquestion *)

{*****************************************************************************
*   Date: 9/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure Pquestion                                                *
*   Module number: 6.1.5.2                                                   *
*   Description: Displays and handles pick type question frames (true/false  *
*                and yes/no).                                                *
*   Passed Variables: istart                                                 *
*   Returns: None                                                            *
*   Global Variables Used: lessonln, choice, lchoice, frame, test, numright, *
*                          nextframe                                         *
*   Global Variables Changed: numright, nextframe                            *
*   Files Read: None                                                         *
*   Files Written: temp1                                                     *
*   Modules Called: FrameHeader                                              *
*   Calling modules: Qframe                                                  *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure Pquestion(istart : integer);

type
 sresponses = packed array [1..5] of char;
```

```
var
 jnum, index : integer;
 answer : sresponses;
 correct, response, groupnum : char;
 pfound, ptrue : boolean;

begin  (* Procedure Pquestion *)

 istart := istart + 1;
 FrameHeader;
 writeln;

 while (lessonln[istart,2] = '2') do
   begin
    for jnum := 3 to 80 do
      write (lessonln[istart,jnum]);
    writeln;
    istart := istart + 1
   end;

 writeln;

 if (lessonln[istart,2] = '3') then
   begin
    correct := lessonln[istart,3];
    istart := istart + 1
   end;

 repeat
  index := 1;
  write ('Enter your choice here ==> ');
  while not (eoln) and (index < 6) do
    begin
     read (answer[index]);
     index := index + 1
    end;
  if (eoln) and (i < 6) then
    begin
     for index := index to 5 do
       answer[index] := ' ';
     readln;
    end
  else
    readln;
  ptrue := false;

  if (answer[1] in ['t','T','f','F','y','Y','n','N']) then
    ptrue := true
  else
    writeln ('Sorry, that is not a valid response. Please try again.');

 until (ptrue);
```

```
case answer[1] of
 't','T','y','Y' : response := 'Y';
 'f','F','n','N' : response := 'N'
end;

writeln (temp1,choice,lchoice,frame:3,correct,response);

if (response = correct) then
  begin
   if (test) then
     numright := numright + 1.0;
   groupnum := '4'
  end
else
  groupnum := '5';

pfound := false;

repeat
 if (lessonln[istart,2] = groupnum) then
   pfound := true
 else
   istart := istart + 1;
until (pfound);

while (lessonln[istart,4] <> 'B') or (lessonln[istart,5] <> ':') do
  begin
   writeln;
   for jnum := 4 to 80 do
     write (lessonln[istart,jnum]);
   istart := istart + 1
  end;

if (lessonln[istart,4] = 'B') and (lessonln[istart,5] = ':') then
  begin
   nextframe := 0;
   for jnum := 6 to 8 do
     nextframe := (10 * nextframe) +
                  ((ord(lessonln[istart,jnum])) - ord('0'))
  end
else
  nextframe := -1

end;   (* Procedure Pquestion *)

(*************************************************)
(* Start of main part of procedure:  Qframe      *)
(*************************************************)

begin  (* Procedure Qframe *)

 if (lessonln[istart,14] = 'M') then
   qtype := 'M'
```

```
    else
      qtype := 'P';

    case qtype of
     'M' : Mquestion(istart);
     'P' : Pquestion(istart)
    end;

    writeln;
    for ivalq := 1 to 27 do
      write (' ');
    write ('Press  RETURN  to continue.');
    readln;

  end;   (* Procedure Oframe *)

  (*****************************************************)
  (* Start of main part of procedure:  ShowTopic  *)
  (*****************************************************)

  begin  (* Procedure ShowTopic *)

    BlankLines;
    ReadLines;
    StorePositions;

    numasked := 0.0;
    numright := 0.0;
    score := 0.0;
    test := false;
    istart := 1;

    frame := 0;
    for j := 9 to 11 do
      frame := (10 * frame) + ((ord(lessonln[istart,j])) - ord('0'));

    if (lessonln[istart,13] = 'T') and (lessonln[istart,14] = 'T') then
      test := true;

    repeat
     if (lessonln[istart,2] = '1') then
       begin
        ftype := lessonln[istart,13];
        if (test) and (ftype = 'O') then
          numasked := numasked + 1.0;
        case ftype of
         'T' : Tframe(istart);
         'O' : Oframe(istart)
        end;
        k := 0;
        sfound := false;
```

```
      repeat
       k := k + 1;
       if (lplace[k].framenum = nextframe) then
         begin
          istart := lplace[k].ivalue;
          frame := lplace[k].framenum;
          sfound := true
         end;
      until (sfound) or (lplace[k].framenum = -1);
     end;

  until not (sfound) or (lplace[k].framenum = -1);

  i := ord(choice) - ord('0');
  j := ord(lchoice) - ord('0');

  if (test) then
    begin
     ClearScreen;
     score := numright/numasked;
     score := (score * 100.0);
     writeln ('Your test score = ',score:-1:2,'%');
     writeln;
     if (score >= MINSCORE) then
       begin
        writeln ('CONGRATULATIONS!  YOU HAVE PASSED THE LESSON TEST.');
        npupil.topics[i,j] := '+';
        npupil.lessons[i] := '+';
        topicstat[j] := '+'
       end
     else
       begin
        writeln ('Sorry, but you missed too many questions to pass the test.');
        writeln;
        write ('I suggest that you review at least one topic before you ');
        writeln ('retake the lesson test.');
        npupil.topics[i,j] := '-';
        npupil.lessons[i] := '-';
        topicstat[j] := '-'
       end
    end
  else
    begin
     ClearScreen;
     npupil.topics[i,j] := '+';
     topicstat[j] := '+'
    end;

end;   (* Procedure ShowTopic *)

(*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
```

```
*                                                                              *
*   Name: procedure RecordStats                                                *
*   Module number: 6.2                                                         *
*   Description: Reads file "STATS" and adds statistical data from current     *
*                session.                                                      *
*   Passed Variables: None                                                     *
*   Returns: None                                                              *
*   Global Variables Used: println                                             *
*   Global Variables Changed: println                                          *
*   Files Read: stats, temp1                                                   *
*   Files Written: temp2, stats                                                *
*   Modules Called: None                                                       *
*   Calling modules: StartLesson                                               *
*                                                                              *
*   Author: Capt Frank W. DeMarco                                              *
*   History:                                                                   *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                         *
********************************************************************************}

procedure RecordStats;

var
 i : integer;

begin  (* Procedure RecordStats *)

 writeln;
 writeln ('One moment please, while I update my records.');
 assign (temp2,'t2');
 assign (statfile,'stats');
 reset (temp1);
 rewrite (temp2);
 reset (statfile);

 repeat
  while not (eof(statfile)) do
    begin
     for i := 1 to 80 do
       println[i] := ' ';
     readln (statfile,println);
     writeln (temp2,println)
    end;
 until (eof(statfile));

 repeat
  while not (eof(temp1)) do
    begin
     for i := 1 to 80 do
       println[i] := ' ';
     readln (temp1,println);
     writeln (temp2,println)
    end;
 until (eof(temp1));
```

```
 reset (temp2);
 rewrite (statfile);

 repeat
  while not (eof(temp2)) do
    begin
     for i := 1 to 80 do
       println[i] := ' ';
     readln (temp2,println);
     writeln (statfile,println)
    end;
 until (eof(temp2));

 rewrite (temp1);
 rewrite (temp2);
 close (temp1);
 close (temp2);
 close (statfile);

end;   (* Procedure RecordStats *)

(*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure StuRec                                                   *
*   Module number: 6.3                                                       *
*   Description: Writes updated student course progress data to file         *
*                "STUDENT".                                                  *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: studentcount, rpupil, npupil                      *
*   Global Variables Changed: none                                           *
*   Files Read: None                                                         *
*   Files Written: student                                                   *
*   Modules Called: None                                                     *
*   Calling modules: StartLesson                                             *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************)

procedure StuRec;

var
 i, ii, j : integer;

begin  (* Procedure StuRec *)

 rewrite (student);
```

```
  for i := 1 to studentcount do
    if (rpupil[i].studentnumber <> npupil.studentnumber) and
     (rpupil[i].studentnumber <> '           ') then
      begin
       write(student,'>');
       for j := 1 to 11 do
         write(student,rpupil[i].studentnumber[j]);
       for j := 1 to 28 do
         write(student,rpupil[i].studentname[j]);
       for j := 1 to MAXLESSONS do
         write(student,rpupil[i].lessons[j]);
       for ii := 1 to MAXLESSONS do
         begin
          if (ii < MAXLESSONS) then
            for j := 1 to MAXTOPICS do
              write (student,rpupil[i].topics[ii,j])
          else
            begin
             for j := 1 to (MAXTOPICS-1) do
               write (student,rpupil[i].topics[ii,j]);
             writeln (student,rpupil[i].topics[ii,MAXTOPICS])
            end;
         end;
      end;

  write(student,'>');
  for i := 1 to 11 do
     write(student,npupil.studentnumber[i]);
  for i := 1 to 28 do
     write(student,npupil.studentname[i]);
  for i := 1 to MAXLESSONS do
     write(student,npupil.lessons[i]);
  for i := 1 to MAXLESSONS do
    begin
     for j := 1 to MAXTOPICS do
       write (student,npupil.topics[i,j])
    end;

  close (student)

end;   {* Procedure StuRec *}

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure StartLesson                                              *
*   Module number: 6.0                                                       *
*   Description: Displays topic choices for a lesson, prompts student for    *
*                choice of topic to be shown. Driver of procedures that      *
*                display lesson material and update statistical & student    *
*                progress files.                                             *
*   Passed Variables: None                                                   *
```

```
*   Returns: None                                                              *
*   Global Variables Used: choice, topicstat, linecount, println, advance,    *
*                          menuln, lchoice                                     *
*   Global Variables Changed: topicstat, linecount, println, advance, menuln, *
*                             lchoice                                          *
*   Files Read: None                                                           *
*   Files Written: None                                                        *
*   Modules Called: ClearScreen, ShowTopic, RecordStats, StuRec                *
*   Calling modules: program CAI                                               *
*                                                                              *
*   Author: Capt Frank W. DeMarco                                              *
*   History:                                                                   *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                         *
********************************************************************************)

procedure StartLesson;

var
 i, j, k, index : integer;
 character : char;

begin  (* Procedure StartLesson *)

 case choice of
  '1' : assign (lesson,'b:lesson1');
  '2' : assign (lesson,'b:lesson2');
  '3' : assign (lesson,'b:lesson3');
  '4' : assign (lesson,'b:lesson4');
  '5' : assign (lesson,'b:lesson5');
  '6' : assign (lesson,'b:lesson6');
 end;

 index := ord(choice) - ord('0');
 for i := 1 to MAXTOPICS do
   topicstat[i] := npupil.topics[index,i];

 reset (lesson);
 read (lesson,character);
 linecount := 0;

 repeat

 while (character = '#') and (linecount < 23) do
   begin
    for i := 1 to 80 do
      println[i] := ' ';
    readln (lesson,println);
    linecount := linecount + 1;
    writeln (println);
    read (lesson,character)
   end;
```

```
if (character = '!') then
  begin
   advance := 23 - linecount;
   linecount := 0;
   for i := 1 to advance do
     writeln;
   for i := 1 to 27 do
     write (' ');
   write ('Press  RETURN  to continue.');
   readln;
   readln (lesson);
   read (lesson,character);
   ClearScreen
  end;

until not (character in ['#','!']);

for i := 1 to 22 do
  begin
   for j := 1 to 80 do
     menuln[i,j] := ' '
  end;

menuln[1,1] := character;
for j := 2 to 79 do
  read (lesson,menuln[1,j]);
readln (lesson,menuln[1,80]);

for i := 2 to 22 do
  begin
   for j := 1 to 79 do
     read (lesson,menuln[i,j]);
   readln (lesson,menuln[i,80])
  end;

repeat
 assign (temp1,'t1');
 rewrite (temp1);
 repeat
  k := 0;
  i := 1;
  while (menuln[i,1] in ['*','@']) do
    begin
     if (menuln[i,1] = '*') then
       begin
        for j := 1 to 79 do
          write (menuln[i,j]);
        writeln (menuln[i,80])
       end
     else
       begin
        k := k + 1;
        write ('*');
```

```
            for j := 2 to 8 do
              write (menuln[i,j]);
            write (topicstat[k]);
            for j := 10 to 79 do
              write (menuln[i,j]);
            writeln (menuln[i,80])
           end;
         i := i + 1
        end;

 writeln;
 write ('ENTER THE TOPIC NUMBER OF YOUR CHOICE OR "X" TO EXIT THIS LESSON: ');
 readln (lchoice);
 if (lchoice in ['1'..VTOPIC,'x','X']) then
   ClearScreen
 else
   begin
    ClearScreen;
    writeln ('Sorry, ',lchoice,' is not a valid response. Please try again.')
   end;

 until (lchoice in ['1'..VTOPIC,'x','X']);

 if (lchoice in ['1'..VTOPIC]) then
   writeln ('You have chosen topic number ',lchoice,'. Thank you.')
 else
   writeln ('OK, I will now return you to the lesson selection menu.');

 if (lchoice in ['1'..VTOPIC]) then
   begin
    ShowTopic;
    RecordStats;
    StuRec;
    ClearScreen
   end;

 until (lchoice in ['x','X']);

 close (temp1);
 close (lesson)

end;   (* Procedure StartLesson *)

{************************************************}
{* Start of main driver:  Program CAI           *}
{************************************************}

begin  (* Program CAI *)

 ClearScreen;
 StartEnd('S');
 Query;
```

```
 if (studentcount <= MAXSTUDENTS) then
   begin
    repeat
     begin
      Select;
      if (choice in ['1'..VLESSON]) then
        StartLesson
     end
    until (choice in ['x','X']);
    StartEnd('E')
   end

end.    (* Program CAI *)
```

Program "STUDENT_STATUS"

```
(**** THIS PROGRAM WAS WRITTEN IN PARTIAL FULFILLMENT OF A MASTERS THESIS ****)
(*****************************************************************************
*   Date: 8/1/85                                                            *
*   Version: 1.0                                                            *
*                                                                           *
*   Title: Program Student_Status                                           *
*   Filename: STATUS.PAS                                                    *
*   Coordinator: Capt Frank W. DeMarco                                      *
*   Project: Masters Thesis                                                 *
*   Operating System: MS-DOS                                                *
*   Language: Pascal                                                        *
*   Use: Compile and link with PASCAL.LIB using MS-Pascal compiler and linker.*
*   Contents: Program Student_Status - Main Driver.                         *
*             Procedure ClearScreen - Clears Z-100 terminal screen.         *
*             Procedure QueryUser - Determines the users preferred method of *
*                                   program output (screen or hardcopy).    *
*             Procedure Header - Produces the program report header.        *
*             Procedure Display - Produces the status report for all students *
*                                 in file "STUDENTS".                       *
*             Procedure EndScreen - Completes the screen display format for *
*                                   the screen method of program output.    *
*                                                                           *
*   Function: The purpose of this program is to provide a means for training *
*             managers, as well as personnel of the CAI Plans Branch (3300  *
*             TCHTW at Keesler AFB, to check student progress in the C CAI  *
*             course.                                                       *
*                                                                           *
*****************************************************************************)

(*****************************************************************************
*   Date: 8/1/85                                                            *
*   Version: 1.0                                                            *
*                                                                           *
*   Name: program Student_Status                                            *
*   Module number: 1.0                                                      *
*   Description: Main driver of program                                     *
*   Passed Variables: None                                                  *
*   Returns: None                                                           *
*   Global Variables Used: studentcount, character, advance, choice         *
*   Global Variables Changed: studentcount, character, advance              *
*   Files Read: student                                                     *
*   Files Written: None                                                     *
*   Modules Called: ClearScreen, QueryUser, Header, Display, EndScreen      *
*   Calling modules: None                                                   *
*                                                                           *
*   Author: Capt Frank W. DeMarco                                           *
*   History:                                                                *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                      *
*****************************************************************************)
```

```
program Student_Status (input,output);

const
 ALINEP1 = '*****************************************';
 ALINEP2 = '*****************************************';
 ADASH = '*---------------------------------------';
 DASHA = '---------------------------------------*';
 NUMLESSONS = 6;
 NUMTOPICS = 30;

type
 iofile = TEXT;

var
 infile : iofile;

 choice, character : char;
 advance, i, studentcount : integer;

{*****************************************************************************
*   Date:  8/1/85                                                            *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure ClearScreen                                              *
*   Module number: 1.1                                                       *
*   Description: Clears Z-100 terminal screen and sets "no-wrap" on EOL.     *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: None                                              *
*   Global Variables Changed: None                                           *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: None                                                     *
*   Calling modules: program Student_Status                                  *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                       *
*****************************************************************************}

procedure ClearScreen;

begin  (* Procedure ClearScreen *)

 write (chr(27),'H',chr(27),'J',chr(27),'w')

end;   (* Procedure ClearScreen *)

{*****************************************************************************
*   Date: 8/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure QueryUser                                                *
```

```
*   Module number: 1.2                                                          *
*   Description: Determines the users preferred method of program output       *
*                (screen or hardcopy).                                          *
*   Passed Variables: choice                                                   *
*   Returns: choice                                                            *
*   Global Variables Used: None                                                *
*   Global Variables Changed: None                                             *
*   Files Read: None                                                           *
*   Files Written: None                                                        *
*   Modules Called: None                                                       *
*   Calling modules: program Student_Status                                    *
*                                                                              *
*   Author: Capt Frank W. DeMarco                                              *
*   History:                                                                   *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                         *
*******************************************************************************)

procedure QueryUser(var choice: char);

begin  (* Procedure QueryUser *)

 write ('The output of this program can be put into two (2) different');
 writeln (' formats.');
 writeln;
 writeln ('If you plan on getting a hard copy; type  H  .');
 writeln ('If you only want a screen display ; type  S  .');

 repeat
  writeln;
  write ('Enter your choice here ==> ');
  readln (choice);
 until (choice in ['h','H','s','S']);

 if (choice in ['h','H']) then
   begin
    writeln;
    writeln ('Press  ^P  (CONTROL P) and then  RETURN  to get printout');
    readln
   end

end;   (* Procedure QueryUser *)

(*******************************************************************************
*   Date: 8/1/85                                                               *
*   Version: 1.0                                                               *
*                                                                              *
*   Name: procedure Header                                                     *
*   Module number: 1.3                                                         *
*   Description: Produces the program report header.                           *
*   Passed Variables: None                                                     *
*   Returns: None                                                              *
*   Global Variables Used: None                                                *
*   Global Variables Changed: None                                             *
```

```
*   Files Read: None                                                          *
*   Files Written: None                                                       *
*   Modules Called: None                                                      *
*   Calling modules: program Student_Status, EndScreen                        *
*                                                                             *
*   Author: Capt Frank W. DeMarco                                             *
*   History:                                                                  *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                        *
*****************************************************************************)

procedure Header;

begin  (* Procedure Header *)

 writeln (ALINEP1,ALINEP2);
 write ('*    THE FOLLOWING IS THE PRESENT STUDENT STATUS FOR STUDENTS ON');
 writeln (' THIS DISK.    *');
 writeln (ALINEP1,ALINEP2);
 write ('*   STUDENT   |  LESSON  |  LESSON  |  LESSON  |  LESSON  |');
 writeln ('  LESSON  |  LESSON *');
 write ('*    ID #     |    #1    |    #2    |    #3    |    #4    |');
 writeln ('    #5    |    #6   *');
 writeln (ADASH,DASHA)

end;   (* Procedure Header *)

(*****************************************************************************
*   Date: 8/1/85                                                              *
*   Version: 1.0                                                              *
*                                                                             *
*   Name: procedure Display                                                   *
*   Module number: 1.4                                                        *
*   Description: Produces the status report for all students in file          *
*                "STUDENTS".                                                  *
*   Passed Variables: character, studentcount                                 *
*   Returns: character, studentcount                                          *
*   Global Variables Used: None                                               *
*   Global Variables Changed: None                                            *
*   Files Read: student                                                       *
*   Files Written: None                                                       *
*   Modules Called: None                                                      *
*   Calling modules: program Student_Status                                   *
*                                                                             *
*   Author: Capt Frank W. DeMarco                                             *
*   History:                                                                  *
*    1.0 Frank W. DeMarco 8/1/85 - input original code                        *
*****************************************************************************)

procedure Display(var character: char;
                  var studentcount: integer);

type
 roll = record
```

```
          studentnumber : packed array [1..11] of char;
          studentname : packed array [1..29] of char;
          lessons : packed array [1..NUMLESSONS] of char;
          topics : packed array [1..NUMTOPICS] of char;
         end;

var
 pupil : roll;

begin  (* Procedure Display *)

 studentcount := studentcount + 1;
 while not (eoln(infile)) do
   begin
    for i := 1 to 11 do
      read (infile,pupil.studentnumber[i]);
    for i := 1 to 28 do
      read (infile,pupil.studentname[i]);
    for i := 1 to NUMLESSONS do
      read (infile,pupil.lessons[i]);
    for i := 1 to NUMTOPICS do
      read (infile,pupil.topics[i]);
   end;

 write ('* ');
 for i := 1 to 11 do
   begin
    if (pupil.studentnumber[i] = '*') then
      write (' ')
    else
      write (pupil.studentnumber[i])
   end;
 write (' |');

 for i := 1 to NUMLESSONS do
   begin
    if (pupil.lessons[i] = '+') then
      write ('  Passed  ')
    else
      begin
       if (i < NUMLESSONS) then
         write ('          ')
       else
         write ('         ')
      end;
    if (i < NUMLESSONS) then
      write ('|')
    else
      writeln ('*');
   end;

 if not (eof(infile)) then
   readln (infile);
```

```
  if not (eof(infile)) then
    read (infile,character);

end;   (* Procedure Display *)

(*****************************************************************************
*   Date: 9/1/85                                                             *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: procedure EndScreen                                                *
*   Module number: 1.5                                                       *
*   Description: Completes the screen display format for the screen method of *
*                program output.                                             *
*   Passed Variables: advance                                                *
*   Returns: None                                                            *
*   Global Variables Used: None                                              *
*   Global Variables Changed: None                                           *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen                                              *
*   Calling modules: program Student_Status                                  *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 9/1/85 - input original code                       *
*****************************************************************************)

procedure EndScreen(advance: integer);

begin  (* Procedure EndScreen *)

 for i := 1 to (advance - 1) do
   begin
    write ('*              !          !          !          !');
    writeln ('          !          !          *')
   end;
 writeln (ALINEF1,ALINEF2);
 for i := 1 to 25 do
   write (' ');
 if not (eof(infile)) then
   begin
    write ('Press  RETURN  to continue.');
    readln;
    ClearScreen;
    Header
   end
 else
   begin
    write ('Press  RETURN  to end program.');
    readln
   end

end;   (* Procedure EndScreen *)
```

```
{*********************************************************}
{* Start of main driver:  Program Student_Status     *}
{*********************************************************}

begin  {* Program Student_Status *}

 ClearScreen;
 QueryUser(choice);
 ClearScreen;
 Header;

 assign (infile,'student');
 reset (infile);
 read (infile,character);

 repeat
  studentcount := 0;
  while (character = '>') and (studentcount < 16) and not (eof(infile)) do
    Display(character,studentcount);
  advance := 23 - (studentcount + 6);
  if (choice in ['s','S']) then
    EndScreen(advance);
 until (eof(infile));

 if (choice in ['s','S']) then
   ClearScreen
 else
   writeln (ALINEP1,ALINEP2)

end.   {* Program Student_Status *}
```

Program "CAI STATISTICS"

```
(**** THIS PROGRAM WAS WRITTEN IN PARTIAL FULFILLMENT OF A MASTERS THESIS ****)
(*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Title: Program CAI_Statistics                                            *
*   Filename: VALIDATE.PAS                                                   *
*   Coordinator: Capt Frank W. DeMarco                                       *
*   Project: Masters Thesis                                                  *
*   Operating System: MS-DOS                                                 *
*   Language: Pascal                                                         *
*   Use: Compile and link with PASCAL.LIB using MS-Pascal compiler and linker.*
*   Contents: PROGRAM CAI_Statistics - Main Driver                           *
*             Procedure ClearScreen - Clears Z-100 terminal screen.          *
*             Procedure QueryUser - Determines the users preferred method of *
*                                   program output (screen or hardcopy).     *
*             Procedure Header - Produces the program report header.         *
*             Procedure Init - Initializes array and two link lists used in  *
*                              the program as well as opening file "STATS".  *
*             Procedure ReadStats - Reads file "STATS" into a linked list of *
*                                   frame records as well as builds an array *
*                                   of unique frame identifiers.             *
*             Procedure Sort - Sorts the frame identifier array into numeric *
*                              order.                                        *
*             Procedure Display - Driver for the procedures that display the *
*                                 statistics for each unique question frame. *
*             Procedure FinalScreen - Wraps up the screen display after all  *
*                                     statistics have been processed.        *
*             Procedure BuildFrameLL - Constructs a linked list of frame re- *
*                                      cords that are of the same frame.     *
*             Procedure InitDisplay - Initilizes variables used in statistical*
*                                     analysis.                              *
*             Procedure ShowStats - Analyzes and displays statistical data   *
*                                   stored in the linked list of frame records*
*                                   (of the same frame).                     *
*             Procedure EndScreen - Wraps up the screen display after there  *
*                                   has been a full screen displayed.        *
*                                                                            *
*   Function: The purpose of this program is to provide a means for the OPR  *
*             at Keesler AFB, to validate course material and teaching effec- *
*             tiveness by analyzing questions asked during lesson and test   *
*             course presentation.                                           *
*                                                                            *
*****************************************************************************)

(*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: program CAI Statistics                                             *
*   Module number: 1.0                                                       *
```

```
*   Description: Main driver of program                                          *
*   Passed Variables: None                                                       *
*   Returns: None                                                                *
*   Global Variables Used: choice, character, stats, linecount, dindx            *
*   Global Variables Changed: dindx                                              *
*   Files Read: stats                                                            *
*   Files Written: None                                                          *
*   Modules Called: ClearScreen, QueryUser, Header, Init, ReadStats, Sort,       *
*                   Display, FinalScreen                                         *
*   Calling modules: None                                                        *
*                                                                                *
*   Author: Capt Frank W. DeMarco                                                *
*   History:                                                                     *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                         *
*******************************************************************************}

program CAI_Statistics (input,output);

const
 ALINEP1 = '*******************************************';
 ALINEP2 = '*******************************************';
 ADASH = '*-----+-----+-----+-----+-----+-----+---';
 DASHA = '--+-----+-----*-----+-----+-----+------*';
 V_LESSONS = '6';

type
 iofile = TEXT;
 statistics = record
               ltframe_num  : integer4;
               c_answer     : char;
               s_response : char;
              end;
 stats_array = array [1..150] of integer4;
 frameclone = ^framerecord;
 framerecord = record
                ltf_num : integer4;
                c_ans : char;
                s_ans : char;
                next  : frameclone
               end;

var
 infile : iofile;
 stats : stats_array;
 temptuff : statistics;
 filehead, framehead, node, filenode, framenode : frameclone;
 character, choice : char;
 advance, linecount, dindx, tot_r, tot_w : integer;
 num_A, num_B, num_C, num_D, num_E, num_Y, num_N : integer;
 num_seen, num_right, num_wrong, percent_right, percent_wrong : real;
```

```
{*****************************************************************************
*   Date: 10/15/85                                                          *
*   Version: 1.0                                                            *
*                                                                           *
*   Name: ClearScreen                                                       *
*   Module number: 1.1                                                      *
*   Description: Clears Z-100 terminal screen and sets "no-wrap" on EOL.    *
*   Passed Variables: None                                                  *
*   Returns: None                                                           *
*   Global Variables Used: None                                             *
*   Global Variables Changed: None                                          *
*   Files Read: None                                                        *
*   Files Written: None                                                     *
*   Modules Called: None                                                    *
*   Calling modules: program CAI_Statistics, FinalScreen, EndScreen         *
*                                                                           *
*   Author: Capt Frank W. DeMarco                                           *
*   History:                                                                *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                    *
*****************************************************************************}

procedure ClearScreen;

begin  {* Procedure ClearScreen *}

 write (chr(27),'H',chr(27),'J',chr(27),'w');

end;   {* Procedure ClearScreen *}

{*****************************************************************************
*   Date: 10/15/85                                                          *
*   Version: 1.0                                                            *
*                                                                           *
*   Name: QueryUser                                                         *
*   Module number: 1.2                                                      *
*   Description: Determines the users preferred method of program output    *
*                (screen or hardcopy).                                      *
*   Passed Variables: choice                                                *
*   Returns: choice                                                         *
*   Global Variables Used: None                                             *
*   Global Variables Changed: None                                          *
*   Files Read: None                                                        *
*   Files Written: None                                                     *
*   Modules Called: None                                                    *
*   Calling modules: program CAI_Statistics                                 *
*                                                                           *
*   Author: Capt Frank W. DeMarco                                           *
*   History:                                                                *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                    *
*****************************************************************************}
```

```
procedure QueryUser(var choice: char);

begin  (* Procedure QueryUser *)

 write ('The output of this program can be put into two (2) different');
 writeln (' formats.');
 writeln;
 writeln ('If you plan on getting a hard copy; type  H  .');
 writeln ('If you only want a screen display ; type  S  .');

 repeat
  writeln;
  write ('Enter your choice here ==> ');
  readln (choice);
 until (choice in ['h','H','s','S']);

 if (choice in ['h','H']) then
   begin
    writeln;
    writeln ('Press  ^P  (CONTROL P) and then  RETURN  to get printout');
    readln
   end;

end;   (* Procedure QueryUser *)

(*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: Header                                                             *
*   Module number: 1.3                                                       *
*   Description: Produces the program report header.                         *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: None                                              *
*   Global Variables Changed: None                                           *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: None                                                     *
*   Calling modules: program CAI_Statistics, EndScreen                       *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                     *
*****************************************************************************)

procedure Header;

begin  (* Procedure Header *)

 writeln (ALINEP1,ALINEP2);
 write ('*    THE FOLLOWING IS A STATISTICAL VALIDATION REPORT FOR THE C ');
 writeln ('CAI COURSE.    *');
```

```
 writeln (ALINEP1,ALINEP2);
 write ('* L # | F # | # A | # B | # C | # D | # E | # Y | # N *');
 writeln (' # R | # W | % R | % W  *');
 writeln (ADASH,DASHA)
end;   (* Procedure Header *)

(*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: Init                                                               *
*   Module number: 1.4                                                       *
*   Description: Initializes array and two link lists used in the program as *
*                well as opening file "STATS".                               *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: stats, filehead, filenode, node, framehead,       *
*                          framenode, character                              *
*   Global Variables Changed: stats, filehead, filenode, framehead, framenode *
*                             character                                      *
*   Files Read: stats                                                        *
*   Files Written: None                                                      *
*   Modules Called: None                                                     *
*   Calling modules: program CAI_Statistics                                  *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                     *
*****************************************************************************)

procedure Init;

var
 i : integer;

begin  (* Procedure Init *)
 for i := 1 to 150 do
    stats[i] := 0;

 filehead := nil;
 new (node);
 filenode := node;
 filehead := filenode;

 framehead := nil;
 new (node);
 framenode := node;
 framehead := framenode;

 assign (infile,'stats');
 reset (infile);
 read (infile,character);
end;   (* Procedure Init *)
```

```
{*****************************************************************************
*   Date: 10/15/85                                                          *
*   Version: 1.0                                                            *
*                                                                           *
*   Name: ReadStats                                                         *
*   Module number: 1.5                                                      *
*   Description: Reads file "STATS" into a linked list of frame records as  *
*                well as builds an array of unique frame identifiers.       *
*   Passed Variables: None                                                  *
*   Returns: None                                                           *
*   Global Variables Used: tempbuff, stats, node, filenode, character       *
*   Global Variables Changed: tempbuff, stats, filenode, character          *
*   Files Read: stats                                                       *
*   Files Written: None                                                     *
*   Modules Called: None                                                    *
*   Calling modules: program CAI_Statistics                                 *
*                                                                           *
*   Author: Capt Frank W. DeMarco                                           *
*   History:                                                                *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                    *
*****************************************************************************}

procedure ReadStats;

var
 i : integer;
 fnumber : integer4;
 inchar : char;
 found : boolean;

begin  (* Procedure ReadStats *)

 fnumber := 0;
 fnumber := (10 * fnumber) + ((ord(character)) - ord('0'));
 for i := 1 to 4 do
   begin
    read (infile,inchar);
    fnumber := (10 * fnumber) + ((ord(inchar)) - ord('0'))
   end;

 tempbuff.ltframe_num := fnumber;
 read (infile,tempbuff.c_answer);
 read (infile,tempbuff.s_response);
 i := 1;
 found := false;
 while (stats[i] <> 0) do
   begin
    if (stats[i] = tempbuff.ltframe_num) then
      found := true;
    i := i+1
   end;
```

```
    if not (found) then
       stats[i] := tempbuff.ltframe_num;
    new (node);
    filenode^.next  := node;
    filenode        := node;
    filenode^.ltf_num := tempbuff.ltframe_num;
    filenode^.c_ans := tempbuff.c_answer;
    filenode^.s_ans := tempbuff.s_response;
    filenode^.next  := nil;
    if not (eof(infile)) then
      readln (infile);
    if not (eof(infile)) then
      read (infile,character);

  end;   (* Procedure ReadStats *)

  {*****************************************************************************
  *   Date: 10/15/85                                                           *
  *   Version: 1.0                                                             *
  *                                                                            *
  *   Name: Sort                                                               *
  *   Module number: 1.6                                                       *
  *   Description: Sorts the frame identifier array into numeric order.        *
  *   Passed Variables: stats                                                  *
  *   Returns: stats                                                           *
  *   Global Variables Used: None                                              *
  *   Global Variables Changed: None                                           *
  *   Files Read: None                                                         *
  *   Files Written: None                                                      *
  *   Modules Called: None                                                     *
  *   Calling modules: program CAI_Statistics                                  *
  *                                                                            *
  *   Author: Capt Frank W. DeMarco                                            *
  *   History:                                                                 *
  *    1.0 Frank W. DeMarco 10/15/85 - input original code                     *
  *****************************************************************************}

  procedure Sort(var stats: stats_array);

  var
   temp : integer4;
   sindx, ival, imax : integer;

  begin  (* Procedure Sort *)

   imax := 0;
   sindx := 1;
   while (stats[sindx] <> 0) do
     begin
      imax := imax + 1;
      sindx := sindx + 1
     end;
```

```
repeat
 sindx := 1;
 for ival := 1 to (imax-1) do
   begin
    temp := stats[sindx];
    if (temp > stats[sindx+1]) then
      begin
       stats[sindx] := stats[sindx+1];
       stats[sindx+1] := temp
      end;
    sindx := sindx + 1
   end;
 imax := (sindx-1);
until (imax = 0);

end;   (* Procedure Sort *)

{*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: Display                                                            *
*   Module number: 1.7                                                       *
*   Description: Driver for the procedures that display the statistics for   *
*                each unique question frame.                                 *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: filenode, filehead, framenode, framehead          *
*   Global Variables Changed: filenode, framenode                            *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: BuildFrameLL, InitDisplay, ShowStats                     *
*   Calling modules: program CAI_Statistics                                  *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                     *
*****************************************************************************}

procedure Display;

{*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: BuildFrameLL                                                       *
*   Module number: 1.7.1                                                     *
*   Description: Constructs a linked list of frame records that are of the   *
*                same frame.                                                 *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: filenode, stats, node, filenode                   *
*   Global Variables Changed: framenode, filenode                            *
```

```
*   Files Read: None                                                          *
*   Files Written: None                                                       *
*   Modules Called: None                                                      *
*   Calling modules: Display                                                  *
*                                                                             *
*   Author: Capt Frank W. DeMarco                                             *
*   History:                                                                  *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                      *
*****************************************************************************)

procedure BuildFrameLL;

begin  (* Procedure BuildFrameLL *)

 if (filenode^.ltf_num = stats[dindx]) then
   begin
    new (node);
    framenode^.next  := node;
    framenode        := node;
    framenode^.ltf_num := filenode^.ltf_num;
    framenode^.c_ans := filenode^.c_ans;
    framenode^.s_ans := filenode^.s_ans;
    framenode^.next  := nil
   end;
 filenode := filenode^.next;

end;   (* Procedure BuildFrameLL *)

(*****************************************************************************
*   Date: 10/15/85                                                            *
*   Version: 1.0                                                              *
*                                                                             *
*   Name: InitDisplay                                                         *
*   Module number: 1.7.2                                                      *
*   Description: Initilizes variables used in statistical analysis.           *
*   Passed Variables: None                                                    *
*   Returns: None                                                             *
*   Global Variables Used: advance, num_seen, num_right, num_wrong,           *
*                          percent_right, percent_wrong, num_A, num_B, num_C  *
*                          num_D, num_E, num_Y, num_N                         *
*   Global Variables Changed: advance, num_seen, num_right, num_wrong,        *
*                          percent_right, percent_wrong, num_A, num_B, num_C  *
*                          num_D, num_E, num_Y, num_N                         *
*   Files Read: None                                                          *
*   Files Written: None                                                       *
*   Modules Called: None                                                      *
*   Calling modules: Display                                                  *
*                                                                             *
*   Author: Capt Frank W. DeMarco                                             *
*   History:                                                                  *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                      *
*****************************************************************************)
```

```
procedure InitDisplay;

begin  {* Procedure InitDisplay *}

 advance   := 0;
 num_seen  := 0.0;
 num_right := 0.0;
 num_wrong := 0.0;
 percent_right := 0.0;
 percent_wrong := 0.0;
 num_A := 0;
 num_B := 0;
 num_C := 0;
 num_D := 0;
 num_E := 0;
 num_Y := 0;
 num_N := 0;

end;   {* Procedure InitDisplay *}

{*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: ShowStats                                                          *
*   Module number: 1.7.3                                                     *
*   Description: Analyzes and displays statistical data stored in the linked *
*                list of frame records (of the same frame).                  *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: framenode, num_right, num_wrong, num_seen, num_A  *
*                          num_B, num_C, num_D, num_E, num_Y, num_N, tot_r    *
*                          tot_w, percent_right, percent_wrong, linecount     *
*                          advance                                           *
*   Global Variables Changed: framenode, num_right, num_wrong, num_seen, num_A*
*                          num_B, num_C, num_D, num_E, num_Y, num_N, tot_r    *
*                          tot_w, percent_right, percent_wrong, linecount     *
*                          advance                                           *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: EndScreen                                                *
*   Calling modules: Display                                                 *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                     *
*****************************************************************************}

procedure ShowStats;

var
 lesson_number, frame_number : integer4;
```

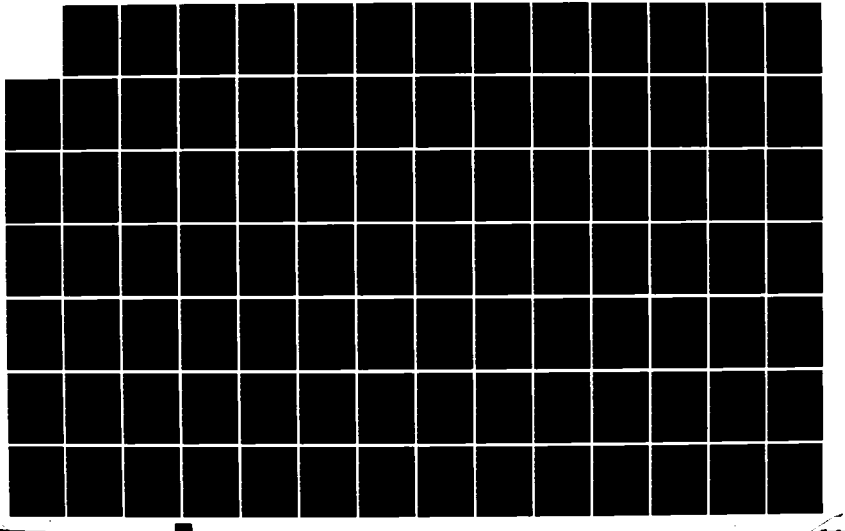
```
{*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: EndScreen                                                          *
*   Module number: 1.7.3.1                                                   *
*   Description: Wraps up the screen display after there has been a full     *
*                screen displayed.                                           *
*   Passed Variables: advance                                                *
*   Returns: None                                                            *
*   Global Variables Used: linecount                                         *
*   Global Variables Changed: linecount                                      *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen, Header                                      *
*   Calling modules: ShowStats                                               *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                     *
*****************************************************************************}

procedure EndScreen(advance: integer);

var
 i : integer;

begin  (* Procedure EndScreen *)

 for i := 1 to (advance - 1) do
   begin
    write ('*     :     :     :     :     :     :     :     :     *');
    writeln ('     :     :     :     *');
   end;
 writeln (ALINEP1,ALINEP2);
 for i := 1 to 26 do
   write (' ');
 write ('Press  RETURN  to continue.');
 readln;
 ClearScreen;
 Header;
 linecount := 0

end;   (* Procedure EndScreen *)

{*****************************************************}
(* Start of main part of procedure:  ShowStats      *)
{*****************************************************}

begin  (* Procedure ShowStats *)

 while (framenode <> nil) do
   begin
```

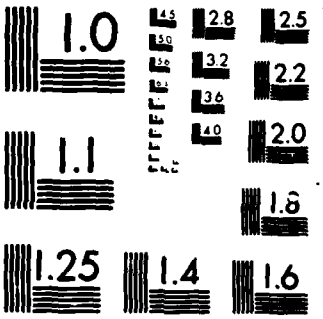
```
      lesson_number := (framenode^.ltf_num div 10000);

      frame_number := (framenode^.ltf_num div 1000);
      frame_number := (frame_number * 1000);
      frame_number := (framenode^.ltf_num - frame_number);

      if (framenode^.s_ans = framenode^.c_ans) then
        num_right := num_right + 1.0
      else
        num_wrong := num_wrong + 1.0;
      num_seen := num_seen + 1.0;
      case framenode^.s_ans of
       'A' : num_A := num_A + 1;
       'B' : num_B := num_B + 1;
       'C' : num_C := num_C + 1;
       'D' : num_D := num_D + 1;
       'E' : num_E := num_E + 1;
       'Y' : num_Y := num_Y + 1;
       'N' : num_N := num_N + 1;
      end;
      framenode := framenode^.next
     end;

   percent_right := ((num_right / num_seen) * 100.0);
   percent_wrong := ((num_wrong / num_seen) * 100.0);
   tot_r := trunc(num_right);
   tot_w := trunc(num_wrong);

   if (linecount < 17) or (choice in ['h','H']) then
     begin
      write ('*  ',lesson_number:1,'  | ',frame_number:3,' | ');
      write (num_A:2,'  | ',num_B:2,'  | ',num_C:2,'  | ',num_D:2,'  | ');
      write (num_E:2,'  | ',num_Y:2,'  | ',num_N:2,'  * ');
      write (tot_r:2,'  | ',tot_w:2,'  |');
      write (percent_right:5:1,'|',percent_wrong:5:1,' *');
      writeln;
      linecount := linecount + 1
     end
   else
     begin
      advance := 22 - (linecount + 5);
      EndScreen(advance)
     end;

  end;   (* Procedure ShowStats *)

  {*******************************************************}
  (* Start of main part of procedure:  Display           *)
  {*******************************************************}

  begin  (* Procedure Display *)

   filenode := filehead^.next;
```

```
framenode := framehead;

repeat
 BuildFrameLL;
until (filenode = nil);

InitDisplay;
framenode := framehead^.next;
ShowStats;

end;   (* Procedure Display *)

{*****************************************************************************
*   Date: 10/15/85                                                           *
*   Version: 1.0                                                             *
*                                                                            *
*   Name: FinalScreen                                                        *
*   Module number: 1.8                                                       *
*   Description: Wraps up the screen display after all statistics have been  *
*                processed.                                                  *
*   Passed Variables: None                                                   *
*   Returns: None                                                            *
*   Global Variables Used: advance, linecount, dindx                         *
*   Global Variables Changed: advance, dindx                                 *
*   Files Read: None                                                         *
*   Files Written: None                                                      *
*   Modules Called: ClearScreen                                              *
*   Calling modules: program CAI_Statistics                                  *
*                                                                            *
*   Author: Capt Frank W. DeMarco                                            *
*   History:                                                                 *
*    1.0 Frank W. DeMarco 10/15/85 - input original code                     *
*****************************************************************************}

procedure FinalScreen;

begin  (* Procedure FinalScreen *)

 advance := 23 - (linecount + 5);
 for dindx := 1 to (advance - 1) do
   begin
    write ('*     !     !     !     !     !     !     !     !     *');
    writeln ('     !     !     !     *');
   end;
 writeln (ALINEP1,ALINEP2);
 for dindx := 1 to 26 do
   write (' ');
 write ('Press  RETURN  to end program.');
 readln;
 ClearScreen

end;   (* Procedure FinalScreen *)
```

AD-A163 042 COMPUTER ASSISTED INSTRUCTION FOR THE 'C' PROGRAMMING LANGUAGE ON THE ZEN..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGI.. F W DEMARCO 2/3

UNCLASSIFIED DEC 85 AFIT/GCS/MA/85D-2 F/G 9/2 NL





MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A

```
{*********************************************************}
{* Start of main driver:  Program CAI_Statistics     *}
{*********************************************************}

begin  {* Program CAI_Statistics *}

 ClearScreen;
 QueryUser(choice);
 ClearScreen;
 Init;

 writeln ('One moment please... reading statistical collection file.');
 while (character in ['1'..V_LESSONS]) and not (eof(infile)) do
   ReadStats;

 Sort(stats);
 Header;

 linecount := 0;
 dindx := 1;
 repeat
  Display;
  dindx := dindx + 1;
 until (stats[dindx] = 0);

 if (choice in ['s','S']) then
   FinalScreen
 else
   writeln (ALINEP1,ALINEP2)

end.   {* Program CAI_Statistics *}
```

Appendix C

Files Used by Program "CAI"

File "INTRO"

```
#     WW     WW  EEEEEEEE  LL          CCCCCCC   000000   MMM  MMM  EEEEEEEE
#     WW WW WW   EE        LL        CC         00    00  MMM  MMM  EE
#     WW WW WW   EEEEE     LL        CC         00    00  MM MM MM  EEEEE
#     WWW  WWW   EE        LL        CC         00    00  MM MM MM  EE
#     WWW  WWW   EEEEEEEE  LLLLLLLL   CCCCCCC   000000   MM    MM  EEEEEEEE
#
#
#                          TTTTTTTTTT    00000000
#                              TT       00      00
#                              TT       00      00
#                              TT       00      00
#                              TT        00000000
#
#
#                         """   CCCCCCCCCCCCCCC   """
#                           ""  CCCCCCCCCCCCCCC  ""
#                               CCC
#                               CCC
#                               CCC
#                               CCC
#                               CCCCCCCCCCCCCCC
#                               CCCCCCCCCCCCCCC
;
#  THE COURSE YOU ARE ABOUT TO TAKE WAS WRITTEN BY CAPT FRANK DEMARCO
#  IN PARTIAL FULFILLMENT OF HIS MASTERS DEGREE IN INFORMATION SYSTEMS.
#
#
#  THIS COURSE IS DESIGNED AS AN INTRODUCTORY LEVEL COURSE FOR THE "C"
#  PROGRAMMING LANGUAGE.  THE OBJECTIVE OF THE COURSE IS TO PROVIDE
#  ENOUGH INFORMATION TO THE STUDENT SO THAT IT MAY BE POSSIBLE FOR
#  THE STUDENT TO BEGIN USING THE "C" LANGUAGE FOR HIS/HER PROGRAMMING
#  NEEDS.
#
#
#  THE COURSE, AS IT CURRENTLY EXISTS, CONSISTS OF SIX LESSONS.
;
```

File "MENU"

```
*****************************************************************************
*                                                                           *
*            SELECT THE LESSON YOU WISH TO TAKE FROM THE FOLLOWING:         *
*                                                                           *
*****************************************************************************
*     STATUS      LESSON #        LESSON TITLE                              *
*     ------      --------        ------------                              *
@                    1            GETTING STARTED WITH C                    *
*                                                                           *
@                    2            VARIABLES, CONSTANTS, OPERATORS, EXPRESSIONS *
*                                                                           *
@                    3            PROGRAM CONTROL STATEMENTS                *
*                                                                           *
@                    4            POINTERS AND ARRAYS                       *
*                                                                           *
@                    5            STRUCTURES                                *
*                                                                           *
@                    6            INPUT AND OUTPUT                          *
*                                                                           *
*****************************************************************************
*      NOTE:  A "STATUS" OF "+" INDICATES LESSON SUCCESSFULLY COMPLETED.    *
*****************************************************************************
```

File "LESSON1"

```
#     WW    WW  EEEEEEEE  LL          CCCCCCC   OOOOOO   MMM  MMM  EEEEEEEE
#     WW WW WW  EE        LL        CC         OO    OO  MMM  MMM  EE
#     WW WW WW  EEEEE     LL        CC         OO    OO  MM MM MM  EEEEE
#     WWW  WWW  EE        LL        CC         OO    OO  MM MM MM  EE
#     WWW  WWW  EEEEEEEE  LLLLLLLL   CCCCCCC   OOOOOO   MM    MM  EEEEEEEE
#
#
#                          TTTTTTTTTT    OOOOOOOO
#                              TT       OO      OO
#                              TT       OO      OO
#                              TT       OO      OO
#                              TT        OOOOOOOO
#
#
#     LL         EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN       111
#     LL         EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NNN   NN     1 111
#     LL         EE        SSS       SSS       OO    OO  NNNN  NN       111
#     LL         EEEEE      SSSS      SSSS     OO    OO  NN NN NN       111
#     LL         EEEEE        SSSS      SSSS   OO    OO  NN NN NN       111
#     LL         EE             SSS       SSS  OO    OO  NN  NNNN       111
#     LLLLLLLL   EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NN   NNN    11111111
#     LLLLLLLL   EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN    11111111
;
#  THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INTRODUCTORY INFORMATION
#  ON THE COURSE AND SOME GENERAL INFORMATION ON  C  PROGRAMMING.
#
#  THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.
#
#
#  The Lesson Breakdown Is As Follows:
#
#  Topic 1:  Introduction to C CAI course - This topic gives a short
#            introduction to the overall course structure and some of
#            the particulars used in the course.  (Approx. time = 5 min.)
#
#
#  Topic 2:  C Program Organization - This topic discusses the overall
#            organization and structure of a typical C program.
#            (Approx. time = 15 min.)
#
#
#  Topic 3:  C Program Environment - This topic gives a description of
#            the overall C programming environment covering such items
#            as "compiling", and "linking".  (Approx. time = 10 min.)
;
#  Lesson Breakdown Continued:
#
#  Topic 4:  Your First C Program - This topic states a problem to be solved
#            and presents a solution for you to help familiarize you with
#            C program statements.  (Approx. time = 10 min.)
```

```
#
#
#  Topic 5:  Lesson 1 Test - This is the lesson test over items that have
#            been presented in the previous four lesson topics.
#            (Approx. time = 5 min.)
#
#
#  TOTAL LESSON TIME IS APPROXIMATELY 45 MINUTES.
#
#
#  I hope that you enjoy it!
!
*******************************************************************************
*                                                                             *
*              SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:          *
*                                                                             *
*******************************************************************************
*                                                                             *
*     STATUS          TOPIC #          TOPIC TITLE                            *
*     ------          -------          -----------                            *
*                                                                             *
@                        1             Introduction to C CAI Course           *
*                                                                             *
@                        2             C Program Organization                 *
*                                                                             *
@                        3             C Program Environment                  *
*                                                                             *
@                        4             Your First C Program                   *
*                                                                             *
@                        5             Test Over Lesson 1                     *
*                                                                             *
*******************************************************************************
*      NOTE:  A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.       *
*******************************************************************************
11Frame 100 T  INTRODUCTION TO C CAI COURSE
12    As a first topic subject I will talk a little about the C programming
12    language computer assisted instruction course as a whole.
12
12    C is considered a low-level general purpose programming language.
12
12    Its classification as a low-level language does not do it justice
12    though.  The language does not provide for, among other things,
12    implicit input or output or for direct file access, but these
12    capabilities can be preformed by the use of explicitly called
12    functions (procedures).
12
12    The C language is a small, straightforward, easy language to learn.
12
12    Let's take a look at what we will be covering in this course.
13B:105
11Frame 105 T
12    This course is broken up into six major subject areas.  Each of
```

```
12    these six areas are further broken into small topic areas.  The
12    goal in organizing the course in this way is to make it easier
12    to understand as well as speed up the process of subject review.
12
12    The following is a lesson breakdown of the course:
12
12    LESSON #       LESSON TITLE
12    --------       ------------
12
12        1          Getting Started With C
12        2          Variables, Constants, Operators, Expressions
12        3          Program Control Statements
12        4          Pointers and Arrays
12        5          Structures
12        6          Input and Output
13B:110
11Frame 110 QM
12Let's see if you have been paying attention.  How many lessons did I say are
12in this course?
13A  Four
13
13B  Five
13
13C+ Six
13
13D  Seven
14 Very good!  You are paying attention.
14 B:115
15ABD No.  The correct answer is Six lessons ("C").
15 B:115
15E I'm sorry, "E" was not one of your choices.
15 B:110
11Frame 115 T
12    What you just saw was an example of one of three types of questions I
12    can ask during the presentation of this course.  The other types are
12    True/False and Yes/No questions.  The responses that I can recognize
12    are as follows:
12
12    Question Type          Valid Responses
12    -------------          ---------------
12
12    Multiple Choice        A, B, C, D, E
12
12    True or False          True, False, T, F
12
12    Yes or No              Yes, No, Y, N
12
12    Note: For True/False or Yes/No questions I will only look at the
12          first letter of your response, so to save time it's best to
12          enter only T, F, Y, or N.  (Answers may be in lower case.)
13B:120
```

```
11Frame 120 QP
12Let's give it a try.
12
12This is an example of a True/False type question.  (True or False)
13Y
14 You are absolutely correct.
14 B:125
15 Wrong!  Are you yanking my electrons?
15 B:125
11Frame 125 T
12    As you will no doubt notice, there is a test at the end of each
12    lesson.  In order for you to receive credit for taking this course
12    you must successfully pass each of these tests.
12
12    There is no set lesson order in taking this course, nor is there a
12    requirement to view each topic before taking a lesson test.  It is
12    suggested that you do take the course in the order established for
12    reasons of material continuity and in order to enhance understanding.
12
12    It is very important that you do not interrupt the CAI program once
12    it has been started.  Your progress is only recorded at the end of
12    each lesson topic.  Please exit the program by answering "X" at the
12    topic selection menu and the lesson selection menu.
12
12    You can check your lesson and topic progress at the selection menus
12    by observing the "status" column displayed.
13B:130
11Frame 130 T
12    While taking this course you can be an invaluable aid in making it
12    better by taking note of errors in the course material.  If you
12    should notice an error or believe something to be in error, just
12    make a note of where the error appears.
12
12    To make this task easier, I display for you all the necessary infor-
12    mation.  Just record the lesson number, topic number, and of course
12    the frame number of the frame where the error appears.  Recording
12    only the frame number will be of little help since each lesson could
12    have a frame with the same number.
12
12    I just have one more thing to mention to you before I return you to
12    the topic selection menu.
13B:135
11Frame 135 T
12    A word about the lesson tests.
12
12    The last lesson topic for each lesson is a test over the material
12    covered in the lesson.  As I mentioned before, these tests must be
12    passed in order to receive credit for taking this course.
12
12    When you take a test, you will be given information during the test
12    which will help you in locating the material that gave you problems
12    on the test.  The way in which this is done is by reference to the
```

```
12    lesson topic and frame number where the material was covered.  An
12    example of two types of feedback you might see are:
12
12    Right.      (2,245)              <OR>              Wrong.      (2,245)
12
12    The reference follows the format of:  (lesson topic #,topic frame #)
12
12                  *** This concludes this topic area. ***
13END
21Frame 300 T  C PROGRAM ORGANIZATION
22    This topic will discuss the overall organization of a typical
22    C program.  For ease of understanding, I will restrict the
22    discussion to a program that is contained in one source file.
22
22
22    The organization of the program file would look like the following:
22
22    1. Preprocessor Statements Section
22
22    2. Global Variable Declarations Section
22
22    3. Function(s)
22
22    4. Main Program Driver
22
22
22    Each of the above will be discussed in this topic section.
23B:305
21Frame 305 T
22    *** Preprocessor Statement Section ***
22
22    Through the use of a preprocessor, the C compiler has the capability
22    of: file inclusion, token substitution, and conditional compilation.
22
22    Preprocessor statement lines are defined in the C program by the use
22    of a  #  as the first character on a line.  These lines may appear
22    anywhere in the program, but it is a good programming practice to
22    place them at the beginning.
22
22
22    We'll take a quick look at each of these preprocessor capabilities.
23B:310
21Frame 310 QM
22Which one of the following is "not" a capability of the C preprocessor?
23A  Conditional Compilation
23
23B  Token Substitution
23
23C+ Function Definition
23
23D  File Inclusion
24 Very good, you're so right.
```

```
24 B:315
25ABD No.  Answer "C" is the correct answer.
25 B:315
25E I'm sorry, "E" was not one of your choices.
25 B:310
21Frame 315 T
22    * File Inclusion *
22
22    The preprocessor control line of the form:  #include "filename"
22    will include the contents of the file specified in the source
22    program file. (Note: The shown quotation marks are needed.)
22
22    In addition, a control line of the form:  #include <filename>
22    will include the contents of the "system" file specified.
22
22    For example:  #include <stdio.h>  is the usual statement for
22    including the file that contains the standard I/O functions
22    for use with C.  We will see more of this later.
22
22    One more thing:  An included file may also have files included.
22
22    This of course should be done cautiously to avoid confusion.
23B:320
21Frame 320 QP
22#include file.dat  is a valid C preprocessor "file inclusion" statement.
22(True or False)
23N
24 That's right. You need to have quotation marks around the file name.
24 B:325
25 Wrong. Quotation marks are needed around the file name.
25 The correct form of the statement is  #include "file.dat" .
25 B:325
21Frame 325 T
22    * Token Substitution *
22
22    The preprocessor control line of the form:
22
22    #define token-name token-replacement
22
22    will substitute the value of the token-replacement for each occurrence
22    of the token-name throughout the program.
22
22    For example:  If you have a value that might change with time, such
22        as a mortgage rate, you could use the #define to make future
22        program changes easier like this ==>  #define interest .11
22
22    It is easy to see that this capability can be a real time saver.  Not
22    only will it make future program changes easier but it will, with wise
22    token-name choices, produce an easier to read and maintain program.
22    Note:  #undef token-name  is used to cancel the token-replacement.
23B:330
```

```
21Frame 330 QM
22Which of the following is a valid C preprocessor "token subtitution"
22statement?
23A  #define pay_grade = 11
23
23B  #declare pay_grade 11
23
23C+ #define pay_grade 11
23
23D  #declare pay_grade = 11
24 Correct.  Keep up the good work.
24 B:335
25A No.  There is no "=" in the valid form of the statement.  Answer "C" is
25  the correct response.
25 B:335
25BD No.  I think you missed something. Let's look at that again.
25 B:325
25E I'm sorry, "E" was not one of your choices.
25 B:330
21Frame 335 T
22    * Conditional Compilation *
22
22    You can cause the compiler to skip sections of your source code by
22    using the conditional preprocessor control statements of:
22    #if, #ifdef, #ifndef, #else, and #endif.
22
22    The statement  #if constant-expression  will evaluate to "true" if
22    the constant-expression is a non-zero value.
22
22    The statement  #ifdef identifier  will evaluate to "true" if the
22    identifier had previously been defined using the #define.
22
22    The statement  #ifndef identifier  will evaluate to "true" if the
22    identifier had not been previously defined using the #define.
22
22    Following the above statements would be statements that you would
22    want to be executed based on the outcome of the statement test.
23B:340
21Frame 340 T
22    * Conditional Compilation Continued *
22
22    The statement  #else  would be used to identify an alternate section
22    of code to be executed if the outcome of the #if.. statement test
22    evaluates to false.
22
22    The statement  #endif  is used to terminate an #if.. #else structure.
22
22    Example:   #ifdef employed   /* check to see if "employed" #define(d) */
22                {
22                 executable statements;
22                }
22               #else             /* else "employed" is not #define(d) */
```

```
22                {
22                 alternate executable statements;
22                }
22               #endif
23B:345
21Frame 345 QP
22#ifndef  is an example of a C preprocessor "conditional compilation"
22statement.  (True or False)
23Y
24 Yes, that's right.
24 B:350
25 Sorry, the answer is "True".
25 B:350
21Frame 350 T
22    *** Global Variable Declarations Section ***
22
22    Whenever a variable is declared independent of a function, it is
22    called a "global" variable.  The "scope of a variable" refers to
22    the area where a declared variable is recognized.  If you intend
22    to use the same variable in different portions of your program,
22    then it may be desirable to declare the variable as being global.
22
22    When you declare a global variable, remember that its "scope" is
22    only those functions (procedures) that physically follow it in the
22    program.  (Note: An exception to this involves the "extern" decla-
22    ration statement which I will cover later.)
22
22    Let's look at an example...
23B:355
21Frame 355 T
22    * Global Variable Declaration Example *
22
22    #include <stdio.h>
22    int sum;              /* Global Variable "sum" */
22    main()   {
22        sum = 100;
22        add();
22        add();
22        printf("%d",sum);
22    }
22    add()    {
22        sum = sum + 100;
22    }
22
22    This program would print out the value 300.
22
22    Don't worry if you don't follow everything in this example. You will.
23B:360
21Frame 360 QM
22The "scope" of a global variable refers to ...
23A  the number of variables affected by the global variable.
23
```

```
23B  the extent the global variable is used in the program.
23
23C  the area preceding the global variable declaration.
23
23D+ the area where a declared global variable is recognized.
23
23E  the mouthwash of the global variable.
24 Right.
24 B:365
25ABC No.  The correct answer is "D".
25 B:365
25E I'm sorry, variables don't have mouths.
25 B:360
21Frame 365 T
22    *** Functions ***
22
22    Following global variable declarations in our typical program example
22    is the area where we define our functions.  The structure of a function
22    looks like this:
22
22    return-type  function-name(arguments, if any)
22       argument declarations, if any
22    {
22       declarations
22       executable statements
22       return statement, if any
22    }
22
22    A function has certain required parts.  Here's an example of a function
22    that fills the requirement:
22                                    function1() {}
23B:370
21Frame 370 T
22    * Functions Continued *
22
22    The previous example of a function is an example of a dummy function.
22    The function doesn't actully do anything, but does qualify as a
22    function.
22
22    Let's look at each of the parts of the function structure.
22
22    The "return-type" in front of the function name identifies the type
22    of result the function will return to the function that called it.
22    If this return-type is not explicitly named, then it defaults to an
22    integer type.  If a function returns a value other than an integer
22    and it is physically located after the calling function then it is
22    also necessary to declare the "function" as that return type in the
22    calling function.
23B:375
21Frame 375 T
22    * Functions Continued *
22
```

```
22    For example:  float numval, function1
22
22    The above statement would be in the declaration section of the
22    function that calls function1.
22
22    The function declaration:  float function1(numval)
22
22    would be used to identify the called function "function1" and state
22    that the value to be returned by this function is of type float.
22    Note: We will discuss "float" later.
22
22    That brings us to the "function-name" part of the function structure.
22
22    The function-name can be of any length but must start with a letter.
22    Note: The character  _  (underscore) is considered a letter in C.
23B:380
21Frame 380 T
22    * Functions Continued *
22
22    The function-name can consist of any combination of letters and digits
22    as long as it starts with a letter and does not spell a C keyword.
22    Note: Keywords will be discussed later.
22
22    Following the function-name is a required set of parentheses  () .
22    Inside the parentheses is where the list of passed arguments goes.
22    Each argument is seperated by a comma and appears in the order in
22    which the calling function lists them in its calling statement.
22
22    Next in our function structure is the area for argument declaration.
22    This is the area where we identify the "types" of the passed arguments.
22
22    For example:  float function1(x,y)
22                        float x, n;    <== argument declaration
23B:385
21Frame 385 QM
22Which of the following is required to follow the function-name in a function
22declaration statement?
23A  " "
23
23B+ ( )
23
23C  / /
23
23D  # #
24 Very good.
24 B:390
25ACD No.  I think your falling asleep.  Let's take a step back.
25 B:380
25E I'm sorry, "E" was not one of your choices.
25 B:385
21Frame 390 T
22    * Functions Continued *
```

```
22
22    If an argument is not explictly declared it defaults to type integer.
22
22    Following the argument declarations is a required set of braces {} .
22    Inside the braces is where the function's declarations, executable
22    statements, and return statement goes.  Each statement in this area,
22    as in the argument declaration area, is terminated by the use of a
22    semi-colon.
22
22    We'll look at each of the three areas between the braces.
23B:395
21Frame 395 QP
22If an argument passed in to a function is not explictly declared its
22"type" defaults to an integer.  (True or False)
23Y
24 You are absolutely correct.
24 B:400
25 No.  That statement is correct.
25 B:400
21Frame 400 T
22  * Functions Continued *
22
22  Here are the three areas between the {} braces.
22
22  1.  A function will usually have a need to have local parameters and
22      variables defined in order to do its job in the program.  The
22      function's declaration section within the braces is where these
22      declarations take place.
22
22  2.  Following the local declarations is the function's executable state-
22      ments.  These are the statements to be executed by the function prior
22      to returning control to the calling function.
22
22  3.  The "return" statement is where you identify the variable that is
22      to be passed back to the calling function.  The "return" statement
22      can be a bit confusing.  There are three forms in which the statement
22      can appear.
23B:405
21Frame 405 T
22    * Functions Continued *
22
22    The most common form of "return" is:  return(expression);
22
22    The "expression" can be any valid expression, such as  value * 2
22    or just  value .  In either case the final value will be passed
22    back to the calling function as the value of the function-name.
22    Remember, it is an integer unless explicitly declared otherwise.
22
22    Another form of the "return" is:  return expression;
22
22    The elimination of the parentheses also eliminates the confusion
22    of whether or not "return" is a function (which it isn't).
```

```
23B:410
21Frame 410 T
22    * Functions Continued *
22
22    The last valid form of "return" is:  return;
22
22    This case has the same effect as leaving out the return statement.
22
22    In either case, no value is returned to the calling function and
22    only global variables used by the function would be changed as a
22    result of the called function being executed.
22
22    Important Note: ** Do Not Use ==>  return();  as this will cause
22                    a compile error since "return" is not a function.
22
22
22    We only have one short area left to cover.  But first a question.
23B:415
21Frame 415 QM
22Which of the following is "not" a valid return statement?
23A  return(expression);
23
23B  return expression;
23
23C+ return();
23
23D  return;
24 Very good!
24 B:420
25ABD Wrong.  That is a valid return statement.  "C" is the invalid one.
25 B:420
25E "E" was not a given choice.  Please try again.
25 B:415
21Frame 420 T
22    *** Main Program Driver ***
22
22    This area of the program is usually located at the end of the source
22    program file.  It is the required function that starts and ends the
22    programs execution.  There must be a function by the name of  main()
22    somewhere in your C program.
22
22    The organization of the function "main()" is the same as for the
22    functions we just covered.  I bet that makes you happy!
22
22
22    Well that about does it for this topic.  Let's take one more look
22    at the overall construction of a typical C program before returning
22    to the topic menu.
23B:425
21Frame 425 T
22    *** Review of C Program Organization ***
22
```

```
22    The organization of the program file would look like the following:
22
22
22    1. Preprocessor Statements Section
22
22    2. Global Variable Declarations Section
22
22    3. Function(s)
22
22    4. Main Program Driver
22
22
22                  *** This concludes this topic area. ***
23END
31Frame 500 T  C PROGRAM ENVIRONMENT
32    This topic will discuss the overall C programming environment.
32
32    We will follow the complete process of creating a C program from the
32    writing of code to the execution of the resultant executable program.
32
32    Although this may sound like a lot to cover, it really isn't.
32
32    To get us started let's take a look at the process as a whole.
32    The following is an outline of the steps we will cover:
32
32    1.  Create Source File
32    2.  Compile Source File
32    3.  Error Correction
32    4.  Link Object Code Files
32    5.  Run Executable Code File
32
32    Let's get started ...
33B:505
31Frame 505 T
32    *** Create Source File ***
32
32    The most important aspect of computer programming in any language is
32    the ability to put your thoughts into computer code.  Many experienced
32    programmers feel that the best way to write clear, concise, effective
32    code is to write in plain english "what" it is that needs to be done.
32
32    Once the "what" has been identified you can start working on the "how"
32    do I do it question.  This brings us to a controversial topic, that of
32    where can I do my best program development?  Do I do it on paper, or
32    do I sit at a computer terminal and "create" as I go.  Well it all
32    depends on who you talk to as to which way is better, but the person
32    who wrote the program your using now perfers to "create" his programs
32    at the computer terminal.  Of course it is not always up to you where
32    you do you programming.  Computer time costs money after all, and you
32    and/or your boss should be concerned about such factors.
33B:510
```

```
31Frame 510 T
32    * Create Source File Continued *
32
32    Whichever way you finally decide to do it, you are going to need a
32    way to put the code you have written into a source file for use on
32    the computer.  This calls for the use of a text editor.  The more
32    familiar you are with the text editor the easier and faster you can
32    input your code into a source file.  Remember, chances are you will
32    have to make error corrections or update your program at some point.
32
32    So, learn your text editor and use it often.
32
32
32    Once you have created your C program source file using a text editor,
32    it is time to compile it.
33B:515
31Frame 515 T
32    *** Compile Source File ***
32
32    At this point in our C program development we have one source file.
32    The next step is to translate the "source code" in the source file
32    into "object code" in an object file.  This translation is accom-
32    plished by the C compiler.
32
32    The C compiler is actually a program that performs three basic
32    functions using three distinct programs.
32
32    1. The C Preprocessor
32
32    2. The C Compiler
32
32    3. The C Assembler
33B:520
31Frame 520 QP
32The C compiler is actually three programs in one.  (True or False).
33Y
34 That's right.  A preprocessor, compiler, and assembler all in one.
34 B:525
35 No.  Are you sure you read that last frame?  Let's see it again.
35 B:515
31Frame 525 T
32    * Compile Source File Continued *
32
32    First, the C "preprocessor" scans the source code for preprocessor
32    statements (# statements) and preforms all indicated actions.
32
32    Second, the C "compiler" translates the C language statements into
32    computer assembly language statements.
32
32    Last, the C "assembler" translates the assembly language statements
32    into the object code and places it in an object file.
32
```

```
32    This last step occurs IF you have not made any C syntax errors!
33B:530
31Frame 530 T
32    *** Error Corection ***
32
32    When you compile your C program, it is possible that you may have
32    made one or two syntax errors.  Don't feel bad, it can happen to
32    even the best programmer (once in a while).  If this unfortunate
32    occurence takes place, you can rest assured that the C compiler
32    will let you know.
32
32    The C compiler will report any syntax errors that it encounters
32    while compiling your source code.  In order to achieve the goal
32    of syntax error free object code, it may be necessary to go through
32    several iterations of "compile & correct".
32
32    This process will require changes to your source file, which is
32    a reason why you should know how to use your text editor program
32    inside and out.
33B:535
31Frame 535 T
32    *** Link Object Code Files ***
32
32    Once you have successfully produced an "object code" file, it is time
32    to move on to creating an executable program file.
32
32    The C "linker" is a program that is used to link together object files
32    into an executable "machine code" file.  The C linker will take all
32    specified object files as well as any needed C library functions
32    and create for you one executable program file.
32
32    This feature allows for the creation of user functions that can be
32    used in a variety of programs by mearly linking them into the new
32    program.  These functions can then be called by the program when
32    needed.  This will save you many hours of redundant work.
32
32    What now?  You ask.  Well you'll see, but first a question.
33B:540
31Frame 540 QM
32Which one of the following programs will create an executable program file
32from one or more object files?
33A  Compiler
33
33B  Chainer
33
33C+ Linker
33
33D  Preprocessor
33
33E  Assembler
34 Correct.
34 B:545
```

```
35ABCE Wrong.  The "Linker" creates the "executable" machine code program file.
35 B:545
31Frame 545 T
32    *** Run Executable Code File ***
32
32    Now that you have the executable program file you can sit back and
32    start the seemingly long process of "logic" testing your program.
32
32    That's right!  It's run time!
32
32    At this point, all syntax errors have been corrected and you have
32    successfully created an executable program file.  Now you can test
32    your program to your heart's content and make all those changes
32    and/or enhancements to your pride-and-joy (your C program).
32
32    Before I return you to the topic selection menu, I would like to
32    give you a picture of the process described in this topic area.
32    I made no mention of "how" to do the steps only "what" steps needed
32    to be done.  The commands to "compile" and "link" differ from system
32    to system, but are similar enough to show an example.
33B:550
31Frame 550 T
32    *** C Environment Example ***
32
32    The following is an example of the steps needed to create and run
32    an executable program file.
32
32
32    1.  Create Source File ========>  progname.c       (using a text editor)
32
32    2.  Compile Source File =======>  cc progname.c    (using C Compiler)
32
32    3.  Error Correction ==========>  (As needed)      (using a text editor)
32
32    4.  Link Object Code Files ====>  clink progname   (using C Linker)
32
32    5.  Run Executable Code File ==>  progname         (type program name)
32
32    6.  Refine Program Execution ==>  (As needed)      (using a text editor)
33END
41Frame 700 T  YOUR FIRST C PROGRAM
42    This topic will develop an actual working C program for you to examine.
42
42    In order to provide a problem solving structure, here is an outline
42    of the steps that I will be discussing:
42
42    1. Problem Definition
42
42    2. English Language Problem Solution
42
42    3. English Language - C Language Translation
42
```

```
42    4. C Language Problem Solution
43B:705
41Frame 705 T
42    *** Problem Definition ***
42
42    The first thing that needs to be done is to define the problem.
42
42
42    The program I want to develop is one that will:
42
42       1. Take a one line input from the keyboard, and
42
42       2. Display the input line "centered" on the terminal screen.
42
42
42    I will show one way to accomplish this and then allow you to choose
42    whether you want to view an alternate solution.
43B:710
41Frame 710 T
42    *** English Language Problem Solution ***
42
42    After thinking out the problem, I arrived at the following five step
42    solution:
42
42    1. Define and initialize the storage area for one line of input.
42
42    2. Prompt user for one line of input.
42
42    3. Read in the one line of input keeping track of number of
42       characters read.
42
42    4. Calculate number of spaces to precede line for "centered" output.
42
42    5. Print out the input line "centered" on screen.
43B:715
41Frame 715 T
42    *** English Language - C Language Translation ***
42
42  Changing the english problem solution into C language statements we get:
42
42  1.    #define CHARIN 80
42        char input_line[CHARIN];
42        for (i=0; i < CHARIN; i++)
42           input_line[i] = ' ';
42  2.    printf("\nPlease enter one (1) line of text to be centered.\n");
42  3.    while ((c = getchar()) != '\n')  {
42           input_line[i] = c;
42           i++;  }
42  4.    advance = (40 - (i / 2));
42  5.    for (ival=0; ival < advance; ival++)
42           putchar(' ');
42        printf("%s",input_line);
```

```
43B:720
41Frame 720 T
42    *** C Language Problem Solution ***
42
42    Now that we have the C statements needed for problem solution, all
42    we need to do is declare the variables we used and put the code
42    into a function called "main".
42
42
42    The following topic frame gives one complete solution.
43B:725
41Frame 725 T
42    #define CHARIN 80
42
42    main()  {
42       char c, input_line[CHARIN];
42       int i, ival, advance;
42
42       for (i=0; i < CHARIN; i++)
42          input_line = ' ';
42       printf("\nPlease enter one (1) line of text to be centered.\n");
42       i = 0;
42       while ((c = getchar()) != '\n')  {
42          input_line[i] = c;
42          i++;  }
42       advance = (40 - (i / 2));
42       for (ival=0; ival < advance; ival++)
42          putchar(' ');
42       printf("%s",input_line);  }
43B:730
41Frame 730 T
42    At this stage of the course, I don't feel that I should take the time
42    to explain each C statement used in this example program.  Please rest
42    assured that I plan to explain all the statements used here as well as
42    a multitude of others later in this course.
42
42    The example solution is by no means the only solution to the stated
42    problem, it is only one of many "correct" solutions.  It also is not
42    a fool proof solution (Input of > 80 characters is not checked for.).
42
42
42    The rest of this topic area contains an alternate solution to this
42    same problem.  Other C statements are shown, but again no explanation
42    is given.
43B:735
41Frame 735 QP
42Do you wish to see another example solution?  (Yes or No)
43Y
44 Great!  Let's take a look at one.
44 B:740
45 Alright.  I will honor your decision.
45 B:780
```

```
41Frame 740 T
42    *** Alternate Solution ***
42
42    In the solution we just finished with, the whole solution was con-
42    tained in the "main" function.  This practice is not a good one to
42    get in the habit of.  A better way to solve programming problems
42    is to break the problem solution into small "modules" or, in the
42    case of C, functions.
42
42    Eariler I identified several steps to be accomplished in order to
42    solve the example problem.  Each main step could be done by its own
42    seperate function or we could combine two or more steps into one
42    function.  Let's see what we end up with if we use this latter
42    approach.
43B:745
41Frame 745 T
42    * Alternate Solution Continued *
42
42    The first step was "Define and initialize the storage area for one
42    line of input."
42
42    This of course can be accomplished using a global variable called
42    "CHARIN" having value 80, an array declaration in function "main"
42    of the form:  char input_line[CHARIN], and a statement that "blanks"
42    out the array using a "for" statement for control.
42
42    These three statements look like the following:
42
42         (1)                        (2)                          (3)
42
42  #define CHARIN 80   ;  char input_line[CHARIN];   ;  for (i=0; i < 80; i++)
42                                                          input_line[i] = ' ';
43B:750
41Frame 750 T
42    The second step of "Prompt user for one line of input" and the third
42    step of "Read in the one line of input keeping track of number of
42    characters read" can be combined into one.
42
42    For this we can define a function called "task1" that would look like:
42
42    task1(input_line, i)
42      char input_line[];
42      int i,
42    {  char c;
42
42       printf("\nPlease enter one (1) line of text to be centered.\n");
42       while ((c = getchar()) != '\n')
42         {  input_line[i] = c;
42            i++;  }
42       return(i);  }
43B:755
```

```
41Frame 755 T
42    The fourth step of "Calculate number of spaces to precede line for
42    'centered' output" and the fifth step of "Print out the input line
42    'centered' on screen" can be combined into one.
42
42    For this we can define a function called "task2" that would look like:
42
42    task2(input_line, i)
42      char input_line[];
42      int i;
42    {  int advance, ival;
42
42       advance = (40 - (i / 2));
42       for (ival=0; ival < advance; ival++)
42          putchar(' ');
42       printf("%s",input_line);  }
43B:760
41Frame 760 T
42    That just leaves one function to write.  That being function "main".
42
42    I will show two different "main" functions that do the same thing.
42
42 main()                          | main()
42   {                             |   {
42    char input_line[CHARIN];      |    char input_line[CHARIN];
42    int i;                       |    int i;
42                                 |
42    for (i=0; i < CHARIN; i++)   |    for (i=0; i < CHARIN; i++)
42       input_line[i] = ' ';      |       input_line[i] = ' ';
42    i = 0;                       |    i = 0;
42    i = task1(input_line, i);    |    task2(input_line, task1(input_line, i));
42    task2(input_line, i);        |   }
42   }                             |
43B:765
41Frame 765 T
42    *** A Variation To The Problem ***
42
42    Now that we have solved the example problem two different ways, how
42    about making a slight improvement to it.  What if we wanted to clear
42    the screen before we displayed the "centered" line on the screen?
42
42    Well, this can be done fairly easily with the following function:
42
42    task3()
42    {
42     putchar('\033');
42     putchar('H');
42     putchar('\033');
42     putchar('J');   }
42
42    Now all we need to do is call "task3" from "task2" before the
42    loop that does the "putchar(' ')".
```

```
43B:770
41Frame 770 T
42    This is what the "task2" function would then look like:
42
42    task2(input_line, i)
42      char input_line[];
42      int i;
42    {  int advance, ival;
42
42       advance = (40 - (i / 2));
42       task3();
42       for (ival=0; ival < advance; ival++)
42          putchar(' ');
42       printf("%s",input_line);  }
42
42    Of course, "task3" would be located ahead of "task2" in the program
42    source file.
43B:775
41Frame 775 T
42    Let's see what our program source file would look like if we use
42    this alternate program solution with the "clear screen" function.
42
42                  #define CHARIN 80
42
42             +--> task3()
42             ¦
42    +-------> +--- task2(input_line, i)
42    ¦
42    ¦  +--------> task1(input_line, i)
42    ¦  ¦
42    +--+--------- main
42
42    The way to read this is:  "main" calls "task1", then "main" calls
42    "task2", then "task2" calls "task3".
43B:780
41Frame 780 T
42    *** Lesson One Summary ***
42
42    Well, that about does it for lesson number one.  If you have seen the
42    four subject topics in this lesson, you should now be ready to take
42    the final test.  If you feel that you don't understand something well
42    enough to pass the test, please retake the topic that is giving you
42    problems.
42
42    Topic 1 gave an introduction to the C CAI course structure.
42
42    Topic 2 gave a description of the C program organization.
42
42    Topic 3 gave a description of the C program environment.
42
42    Topic 4 presented a programming example for your inspection.
```

```
42
42    Good Luck on the test.
43END
51Frame 900 TT TEST OVER LESSON 1
52    Welcome to the final test of lesson one.  This test consists of ten
52    questions over material presented in the previous four topic areas.
52
52    In order to successfully complete this lesson, you must achieve a
52    minimum score of 70% (seven out of ten questions correct).
52
52    If you miss a question, the correct answer will not be shown.  It is
52    up to you to research the correct answer.
52
52    Well, enough said.  Let's get on with it.  Good luck!
53B:905
51Frame 905 QM
521.  After answering a test question in this course, a reference is shown
52to you so that you can find the place in the lesson where the question
52originated.  The reference is in the format of (#,@) where ...
53A  # = lesson number  and  @ = frame number
53
53B+ # = lesson topic number  and  @ = topic frame number
53
53C  # = lesson topic number  and  @ = lesson line number
53
53D  # = lesson number  and  @ = lesson topic number
54 Right.      (1,135)
54 B:910
55ACD Wrong.      (1,135)
55 B:910
55E "E" was not one of your choices.
55 B:905
51Frame 910 QP
522.  The three capabilities of the C preprocessor are:  file inclusion,
52token substitution, and conditional compilation.  (True or False)
53Y
54 Right.      (2,305)
54 B:915
55 Wrong.      (2,305)
55 B:915
51Frame 915 QM
523.  Which of the following is a valid C preprocessor "token subtitution"
52statement?
53A+ #define interest .09
53
53B  #declare interest .09
53
53C  #define interest = .09
53
53D  #declare interest = .09
54 Right.      (2,315)
54 B:920
```

```
55BCD Wrong.      (2,315)
55 B:920
55E "E" was not one of your choices.
55 B:915
51Frame 920 QM
524.  Which of the following is "not" a valid C preprocessor "conditional
52compilation" statement?
53A  #if
53
53B  #ifdef
53
53C  #else
53
53D+ #for
53
53E  #ifndef
54 Right.      (2,320)
54 B:925
55ABCE Wrong.      (2,320)
55 B:925
51Frame 925 QP
525.  The function name in a function declaration can consist of any
52combination of letter, digits, or characters on the keyboard.
52(True or False)
53N
54 Right.      (2,355)
54 B:930
55 Wrong.      (2,355)
55 B:930
51Frame 930 QM
526.  Which of the following is the required function in a C program that
52usually starts and ends execution of the program?
53A  start()
53
53B  begin()
53
53C+ main()
53
53D  driver()
54 Right.      (2,320)
54 B:935
55ABD Wrong.      (2,320)
55 B:935
55E "E" was not one of your choices.
55 B:930
51Frame 935 QM
527.  Which of the following is a list of the three programs contained in
52the C compiler?
53A  Preprocessor, Compiler, Linker
53
53B+ Preprocessor, Compiler, and Assembler
```

```
53
53C  Compiler, Assembler, and Linker
53
53D  Editor, Preprocessor, Assembler
54 Right.      (3,515)
54 B:940
55ACD Wrong.      (3,515)
55 B:940
55E "E" was not one of your choices.
55 B:935
51Frame 940 QP
528.  The C "Linker" is a program that is used to link together one or more
52object files into an executable "machine code" file.  (True or False)
53Y
54 Right.      (3,530)
54 B:945
55 Wrong.      (3,530)
55 B:945
51Frame 945 QM
529.  Which of the following is a "Compiler" program that translates the
52C language statements into assembly language statements?
53A  Editor
53
53B  Preprocessor
53
53C+ Compiler
53
53D  Assembler
53
53E  Linker
54 Right.      (3,520)
54 B:950
55ABDE Wrong.      (3,520)
55 B:950
51Frame 950 QM
5210.  What is the first thing that needs to be done when solving a computer
52programming problem?
53A+ Define the problem to be solved.
53
53B  Write the "english" language solution.
53
53C  Do an "english" to "C" language translation.
53
53D  Write the "C" language solution.
54 Right.      (4,700)
54 B:955
55BCD Wrong.      (4,700)
55 B:955
55E "E" was not one of your choices.
55 B:950
```

```
51Frame 955 T
52    *** End of Lesson Material ***
52
52    This marks the end of lesson number one.  I hope that it was of some
52    benefit to you.  I am looking forward to seeing you in lesson number
52    two.  I hope that you didn't have too much trouble with the material
52    presented in this lesson.  If you did, please voice your comments to
52    your training monitor who will in turn contact the CAI Plans Branch
52    at Keesler AFB, MS.
52
52    Well, let's take a look at how you did with the test ...
53END
```

File "LESSON2"

```
#     WW    WW  EEEEEEEE  LL          CCCCCCC   OOOOOO   MMM  MMM  EEEEEEEE
#     WW WW WW  EE        LL        CC         OO    OO  MMM  MMM  EE
#     WW WW WW  EEEEE     LL        CC         OO    OO  MM MM MM  EEEEE
#     WWW  WWW  EE        LL        CC         OO    OO  MM MM MM  EE
#     WWW  WWW  EEEEEEEE  LLLLLLLL   CCCCCCC   OOOOOO   MM    MM  EEEEEEEE
#
#
#                          TTTTTTTTTT    OOOOOOOO
#                              TT       OO      OO
#                              TT       OO      OO
#                              TT       OO      OO
#                              TT        OOOOOOOO
#
#
#     LL        EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN     22222
#     LL        EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NNN   NN    2222222
#     LL        EE        SSS        SSS       OO    OO  NNNN  NN    2    22
#     LL        EEEEE      SSSS       SSSS     OO    OO  NN NN NN         222
#     LL        EEEEE        SSSS       SSSS   OO    OO  NN NN NN       222
#     LL        EE             SSS        SSS  OO    OO  NN  NNNN     22
#     LLLLLLLL  EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NN   NNN    22222222
#     LLLLLLLL  EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN    22222222
;
#  THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INFORMATION ON VARIABLES,
#  CONSTANTS, OPERATORS, AND EXPRESSIONS USED IN  C  PROGRAMMING.
#
#  THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.
#
#
#  The Lesson Breakdown Is As Follows:
#
#  Topic 1:  Variables & Constants I - This topic is the first of two that
#            covers the declaration and use of variables and constants in
#            C programming.  (Approx. time = 10 min.)
#
#
#  Topic 2:  Variables & Constants II - This topic is the second of two that
#            covers the declaration and use of variables and constants in C
#            programming.  (Approx. time = 5 min.)
#
#
#  Topic 3:  Operators & Expressions I - This topic is the first of two that
#            covers the use of the different operators and expressions in
#            C programming.  (Approx. time = 15 min.)
;
#  Lesson Breakdown Continued:
#
#  Topic 4:  Operators & Expressions II - This topic is the second of two that
#            covers the use of the different operators and expressions in C
#            programming.  (Approx. time = 10 min.)
```

```
#
#
#  Topic 5:  Lesson 2 Test - This is the lesson test over items that have
#            been presented in the previous four lesson topics.
#            (Approx. time = 5 min.)
#
#
#  TOTAL LESSON TIME IS APPROXIMATELY 45 MINUTES.
#
#
#  I hope that you enjoy it!
!
*****************************************************************************
*                                                                           *
*             SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:         *
*                                                                           *
*****************************************************************************
*                                                                           *
*     STATUS          TOPIC #           TOPIC TITLE                         *
*     ------          -------           -----------                         *
*                                                                           *
@                       1               Variables & Constants I             *
*                                                                           *
@                       2               Variables & Constants II            *
*                                                                           *
@                       3               Operators & Expressions I           *
*                                                                           *
@                       4               Operators & Expressions II          *
*                                                                           *
@                       5               Test Over Lesson 2                  *
*                                                                           *
*****************************************************************************
*      NOTE:  A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.     *
*****************************************************************************
11Frame 100 T  VARIABLES & CONSTANTS I
12    *** Data Types ***
12
12    In C there are four sets of basic data types that can be used.
12    These four are:  Character, Integer, Floating point, and Double-
12    precision floating point.
12
12    We will cover the character and integer data types in this topic area,
12    and leave floating point and double-precision floating point for the
12    next topic area.
12
12    I will be discussing the declaration and use of both variables and
12    constants within the context of data type useage.
12
12    The flow of this topic area will follow the following outline:
12
12    1. Character Constants          3. Integer Constants
12    2. Character Variables          4. Integer Variables
```

```
13B:105
11Frame 105 T
12    *** Variable Names ***
12
12    Before we get too far into this area, we need to set up some rules
12    for naming any variables that we use in our programming.
12
12    1. Variable names must begin with a letter.
12    2. Variable names are composed of letters and digits.
12    3. Variable names must not be C keywords.
12
12    In C, a "letter" is any character in the set {a..z,A..Z,_}, that's
12    all lower and upper case letters as well as the "underline" character.
12    A "digit" is any character in the set {0..9}.  A "keyword" is any word
12    in the set:
12
12    {auto, break, case, char, continue, default, do, double, else, entry,
12     extern, float, for, goto, if, int, long, register, return, short,
12     sizeof, static, struct, switch, typedef, union, unsigned, while}
13B:110
11Frame 110 T
12    * Variable Names Continued *
12
12    A few additional facts need to be mentioned about variable names.
12
12    1. Upper and lower case names are different.  This means that the
12       variable names: answer, Answer, and ANSWER are all different
12       variable names.
12
12    2. Only the first eight characters of a variable name are significant.
12       This means that insert_A1 and insert_A2 are the same variable name.
12
12    3. The number of significant characters may be less than eight for
12       external variables and function names (system dependent).
13B:115
11Frame 115 QM
12Which of the following is "not" a valid variable name?
13A  X123
13
13B  first_num
13
13C+ 2nd_in_line
13
13D  _OUT_
14 Very good!
14 B:120
15ABD No.  The correct answer is "C".  Variable names must start with a letter.
15 B:120
15E I'm sorry, "E" was not one of your choices.
15 B:115
11Frame 120 T
12    ***  Character Constants ***
```

```
12
12    A character constant is symbolized as a single character enclosed
12    within single quotation marks.
12
12    For example:  'a'
12
12    The value of a character constant is actually the numeric equivalent
12    of the character as defined by the computer system's character set.
12    Thus, arithmetic operations using characters is possible but the most
12    common use for character constants is for comparitive purposes.
12
12    All this may seem confusing, but it really isn't.  We will look at an
12    example of the useage of character constants after we take a look at
12    character variables.
13B:125
11Frame 125 T
12    *** Character Variables ***
12
12    A character variable is declared by the use of the keyword:  char
12
12    For example:  char in_char;
12
12    The character variable "in_char" will now be assigned a one byte
12    storage location in the computer's memory.  The value that will
12    be stored in this location depends on the useage of the variable
12    in the program.  Let's look at a couple examples that should help
12    you understand both character variables as well as character con-
12    stants.
12
12    The statement:  in_char = 'a';  assigns the ASCII value 97 (decimal)
12    to the character variable location identified by "in_char" in memory.
12    Note:  ASCII values range from 0 thru 127 (decimal) and can be found
12           in most good programming books.
13B:130
11Frame 130 T
12    * Character Variables Continued *
12
12    Every character on the keyboard has an ASCII numeric equivalent.
12    (By the way, ASCII stands for American Standard Code for Information
12    Interchange.)  There are, however, several characters that are hidden.
12    These characters can be represented by character constants by using
12    character escape sequences that start with a backslash (\).
12
12    Some of the more common character escape sequences follow:
12
12    \b   (backspace)
12    \n   (new line)
12    \f   (form feed)
12    \r   (carriage return)
12    \\   (backslash)
12    \'   (single quotation)
12    \###  (### = an octal value)
```

```
13B:135
11Frame 135 T
12    * Character Variables Continued *
12
12    An example of how you would declare a character variable using one of
12    the special character escape sequences as a character constant is as
12    follows:
12
12    char back_space = '\b';
12
12    This statement assigns the ASCII value 8 (decimal) to the character
12    variable location identified by "back_space" in memory.
12
12    An equivalent way to declare the variable "back_space" is as follows:
12
12    char back_space = '\010';     OR     char back_space = '\10';
12
12    In both statements, the character variable location "back_space" is
12    assigned the value 10 (octal) which is equivalent to 8 (decimal).
13B:140
11Frame 140 QP
12In the statement:  char input_char = 't';
12
12input_char is called a character variable and 't' is called a
12character constant.  (True or False)
13Y
14 That's right.
14 B:145
15 Wrong.  That is a true statement.
15 B:145
11Frame 145 QM
12Which one of the following characters is used to identify a special character
12escape sequence?
13A  $
13
13B  @
13
13C  &
13
13D+ \
13
13E  #
14 Very good, you're so right.
14 B:150
15ABCE No.  Answer "D" is the correct answer.
15 B:150
11Frame 150 T
12    *** Character Constants and Variables Summary ***
12
12    So far in this topic area you have seen rules over selecting variable
12    names, a description and examples of character constants, a description
12    an examples of character variables, and a description and examples of
```

```
12    how to declare special characters.
12
12    In the remainder of this topic area we will look at integer constants
12    and integer variables.
12
12    So let's get to it ...
13B:155
11Frame 155 T
12    *** Integer Size ***
12
12    The first thing we need to cover when talking about integers is the
12    size of a number that can be used.  In C we can normally use integers
12    in the range:  -32,768 thru +32,767
12
12    If it is necessary to use a number outside this range, C provides a
12    way to accomplish this.
12
12    The use of an "unsigned" integer provides for use of numbers in the
12    range:  0 thru 65,535
12
12    The use of a "long" integer will provide for use of numbers in the
12    range:  -2,000,000,000 thru +2,000,000,000
12
12    The way to identify which size you are using will be explained.
13B:160
11Frame 160 T
12    *** Integer Constants ***
12
12    An integer constant can be expressed in one of three ways.  It can
12    be decimal, octal, or hexadecimal.  Also, each of these can be either
12    a "short" or "long" integer.
12
12    Decimal integer constants are represented by such numbers as:  238,
12    45920, and -72.  Note that embedded commas are not used.  45,920
12    would be wrong.
12
12    Octal integer constants are represented by such numbers as:  089, 0150,
12    and 014.  Note that "octal" numbers all have a leading "zero".
12
12    Hexadecimal integer constants are represented by such numbers as:  0x8F
12    0X9f, 0X2A, and 0x7b.  Note that lower case and upper case can be used
12    and "hexadecimal" numbers all have a leading "zero x".
13B:165
11Frame 165 T
12    * Integer Constants Continued *
12
12    As I mentioned, integer constants can also be either a "short" or
12    "long" integer.  An integer will be stored as a "short" integer unless
12    you indicate otherwise.  There is, of course, exceptions to the rule.
12    For example, if you specify an integer that is larger than 32767, then
12    it will be stored as a long integer.
12
```

```
12    The way to indicate that an integer is to be stored as a "long" integer
12    is to follow the number with the letter "L".  Here are a few examples.
12
12    Decimal:  5987L, and 367L
12    Octal:  04689L, and 0824L
12    Hexadecimal:  0X2A5F4L, and 0x6FDAL
12
12    Note:  A lowercase letter "l" may be used, but may be very confusing.
13B:170
11Frame 170 QM
12Which of the following best describes the integer constant 073564L ?
13A  Decimal
13
13B  Long Decimal
13
13C  Octal
13
13D+ Long Octal
13
13E  Hexadecimal
14 Right.
14 B:175
15AE No.  The "0" (zero) in front makes it an "octal" and the "L" makes it a
15  "long" integer.  I think you need to review this material.
15 B:160
15B No.  The "0" (zero) in front makes it an "octal" number.
15 B:175
15C No.  The "L" after the number makes it a "long" octal number.
15 B:175
11Frame 175 T
12    *** Integer Variables ***
12
12    An integer variable is declared by the use of the keyword:  int
12
12    For example:  int index;
12
12    The integer variable index will now be assigned a 16 bit storage
12    location in the computer's memory.
12
12    Let's look at a couple examples that should help you understand
12    both integer variables as well as integer constants.
12
12    The statement:  number_in = 212;  assigns the integer constant value
12    212 (decimal) to the integer variable location identified by "number_in"
12    in memory.
13B:180
11Frame 180 T
12    * Integer Variables Continued *
12
12    When declaring an integer variable, you have the option of specifing
12    whether the variable is to be a "short", "long", or "unsigned" variable.
12
```

```
12    The way to indicate which of these an integer variable will be is by
12    using the keywords short, long, or unsigned.  Here are some examples:
12
12    short int index_1; -----> Or Just -----> short index_1;
12
12    long int index_2; -----> Or Just -----> long index_2;
12
12    unsigned int index_3; -----> Or Just -----> unsigned index_3;
12
12    Note:  When using these keywords, use of "int" is optional.
13B:185
11Frame 185 QP
12When declaring an integer variable, you only have the option of specifing
12the variable as being either "short" or "long".  (True or False)
13N
14 That's right.  You can also specify it as being "unsigned".
14 B:190
15 Wrong.  You can also specify it as being "unsigned".
15 B:190
11Frame 190 T
12    * Integer Variables Continued *
12
12    One last word on integers.
12
12    Although C has the capability of specifing different size storage
12    locations, this capability is limited by the specific compiler and
12    system you are using.  Please check to see if your compiler and
12    system treat integers as described here.
13B:195
11Frame 195 T
12    *** Topic Summary ***
12
12    In this topic area we have looked at a description and examples of
12    character constants, character variables, integer constants, and
12    integer variables.  Also we covered variable names and special
12    characters.
12
12    In the next topic area we will continue to discuss constants and
12    variables by looking at floating point and double-precision float-
12    ing point data types.
12
12
12                  *** This concludes this topic area. ***
13END
21Frame 300 T  VARIABLES & CONSTANTS II
22    *** Data Types ***
22
22    We learned in the last topic area that there are four basic data
22    types used in C.  These four are:  Character, Integer, Floating
22    point, and Double-precision floating point.
22
22    We covered the character and integer data types in the last topic area,
```

```
22    so we will cover floating point and double-precision floating point in
22    this topic area.
22
22    I will be discussing the declaration and use of both variables and
22    constants within the context of data type useage.
22
22    The flow of this topic area will follow the following outline:
22
22    1. Floating Point and Double-precision Floating Point Constants
22    2. Floating Point Double-precision Floating Point Variables
23B:305
21Frame 305 T
22    *** Floating Point and Double-precision Floating Point Constants ***
22
22    Floating point numbers are just numbers that have two parts instead of
22    one, as in the case of an integer.  You can think of a floating point
22    number as having an integer, or whole part, and a fractional part.
22
22    These two parts are seperated by a decimal point.
22
22    Examples of floating point numbers:  67.32, 2583.1, and 2.4592
22
22    How "precise" a number is has an effect on calculations preformed using
22    a stored number.  Thus, the precision of a number may be very important
22    within your program.  C stores all floating point constants as double
22    precision.  This means that a large number of significant digits are
22    stored to represent the number and hence, gives better precision in any
22    calculations preformed involving the number.
23B:310
21Frame 310 T
22    * FP & DPFP Constants Continued *
22
22    Another way of representing floating point numbers is through the use
22    of "scientific notation".  The following are examples of the use of
22    scientific notation for floating point constants:
22
22    4.67E3 <or> 4.67e3  =  4670.0
22    .9834E2  =  98.34
22    345.0e6  =  345000000.0
22    -2.8473E5  =  -284730.0
22
22    4.67E-3 <or> 4.67e-3  =  .00467
22    .9834E-2  =  .009834
22    345.0e-6  =  .000345
22    -2.8473E-5  =  -.000028473
22
22    Note:  The "E" can be upper or lower case ("e").
23B:315
21Frame 315 QM
22Which of the following is "not" an example of a floating point constant?
23A  4670.0
23
```

```
23B  .9834e-2
23
23C+ 345
23
23D  -2583.1
23
23E  -67.9E3
24 Correct.
24 B:320
25ABDE Wrong.  Answer "C" is an "integer".
25 B:320
21Frame 320 T
22    *** Floating Point and Double-precision Floating Point Variables ***
22
22    In C, floating point variables are declared using the keyword "float",
22    and double precision floating point numbers are declared using the
22    the keyword "double".
22
22    Here are some examples:
22
22    float var_1;              |      double var_1;
22    float var_2, var_3;       |      double var_2, var_3;
22
22    The following illustrates the use of floating point constants and
22    variables.
22
22    float var_1 = 451.29       <or>  float var_1 = 4.5129E2
22   double var_2 = 23975.5619   <or>  double var_2 = 2.397535619e4
23B:325
21Frame 325 T
22    * FP & DPFP Variables Continued *
22
22    To reiterate, the use of "double" allows for the storing of a greater
22    number of significant digits to represent a given number.  Thus, more
22    precision is gained in calculations involving the number.
22
22    Another way of achieving the precision of a double precision variable
22    is with the keyword "long".  The following two statements have the
22    same effect:
22
22            double var_1;  >>>>>> OR >>>>>>  long float var_1;
23B:330
21Frame 330 QP
22In the statement  double var_one = 419.9253;  the keyword "double" is used
22to indicate that variable "var_one" is to be stored as a "double precision
22floating point" number.  (True or False)
23Y
24 Very good.
24 B:335
25 No.  That statement is true.
25 B:335
21Frame 335 T
```

```
22    *** Topic Summary ***
22
22    In this topic area we have looked at a description and examples of
22    floating point and double precision floating point constants, and
22    floating point and double precision floating point variables.
22
22    In the next topic area we will begin a discussion of operators and
22    expressions and their use in C.
22
22
22                  *** This concludes this topic area. ***
23END
31Frame 500 T  OPERATORS & EXPRESSIONS I
32    *** Introduction ***
32
32    In this and the next topic area we will be discussing operators and
32    their use in expressions.
32
32    This first topic area will cover the following:
32
32    1. Arithmetic Operators
32    2. Increment & Decrement Operators
32    3. Assignment Operators
32
32
32    Let's get started ...
33B:505
31Frame 505 T
32    *** Arithmetic Operators ***
32
32    The arithmetic operators are represented by the following:
32
32    Addition (+), Subtraction (-), Multiplication (*), Division (/),
32    Modulus (%), and the Unary minus (-).
32
32    The first four in this list are probably the most familiar to you so
32    I will only give one example of their use in an expression.
32
32    Addition:  a + b  (adds b to a)
32
32    Subtraction:  a - b  (subtracts b from a)
32
32    Multiplication:  a * b  (multiplies a by b)
32
32    Division:  a / b  (divides a by b)
33B:510
31Frame 510 T
32    * Arithmetic Operators Continued *
32
32    The modulus operator can be used only with integer (int) data types.
32
32    The action preformed by this operator is one of returning the remainder
```

```
32    after a division operation.  For example, in the statement:
32
32    Answer = 15 % 2;  the value stored in "Answer" would be 1, since 15
32                      divided by 2 is 7 with a remainder of 1.  Likewise:
32
32    Result = 150 % 15;  produces a value of 0 in "Result", since 15 divides
32                        150 evenly.
33B:515
31Frame 515 T
32    * Arithmetic Operators Continued *
32
32    The unary minus operator is used to change the sign of the operand it
32    operates on.
32
32    The action preformed by this operator is one of returning the negative
32    of the value of the operand.  For example, in the statement:
32
32    Answer = -x_value;  the value stored in "Answer" would be the negative
32                        of the value stored in "x_value".  For instance:
32
32    If the value stored in "x_value" is 385, then the value stored in the
32    variable "Answer" would be -385.  Likewise, if the value in "x_value"
32    were -952, then "Answer" would contain the value 952.
32
32    Note:  C does not have a unary plus operator.
33B:520
31Frame 520 QM
32Which of the following is the value that will be assigned to the variable
32"Answer" after execution of the statement:  Answer = 27 % 12; ?
33A  2.25
33
33B+ 3
33
33C  .25
33
33D  2
34 Very good.
34 B:525
35ACD No.  The modulus operator returns the "remainder" of "integer" division,
35    therefore answer "B" is correct.
35 B:525
35E I'm sorry, "E" was not one of your choices.
35 B:520
31Frame 525 T
32    *** Increment & Decrement Operators ***
32
32    The increment and decrement operators are represented by the following:
32
32    Increment (++)     and     Decrement (--)
32
32    These two operators can be used in either "prefix" or "postfix"
32    notation.
```

```
32
32    "Prefix" notation results in the variable being incremented or decre-
32    mented before its value is taken.  Whereas, "postfix" notation results
32    in taking the variable value before it is incremented or decremented.
32
32    Let's take a look at each of these operators and see how "prefix" and
32    "postfix" affects them.
33B:530
31Frame 530 T
32    * Increment Operator *
32
32    In the statement:  x_value = x_value + 1;  the value of x_value is
32    incremented by 1 and restored in the memory location identified by
32    the variable "x_value".  This is a valid statement in C, but C also
32    allows a shorthand way of doing the same thing.  In this shorthand
32    notation, the statement would be written as  x_value++;  Thus:
32
32    x_value = x_value + 1;    and    x_value++;  are equivalent statements.
32
32    The above example also demonstrates the use of "postfix" notation.
32    The same result could have been obtained by using "prefix" notation.
32    If you were to use the statement:  ++x_value;  the stored value of
32    "x_value" would have been incremented by 1 as it was using the other
32    two statements.  Where's the difference then?  Well, let's look at
32    another example and see if it becomes clearer.
33B:535
31Frame 535 T
32    * Increment Operator Continued *
32
32    If we assign the value of 10 to the variable "x_value" using the
32    statement:  x_value = 10;  and then preform some arithmetic operation
32    using the variable "x_value" and the increment operator, what would be
32    the result?
32
32    Well, it all depends on whether you use "prefix" or "postfix" notation.
32
32    If we preform the statement:  Result = ++x_value;  then the value
32    stored in "Result" is 11, and "x_value" is incremented to 11, but
32    if we preform the statement:  Result = x_value++;  then the value
32    stored in "Result" is 10, and "x_value" is incremented to 11.
32
32    As you can see, this can be confusing until you get used to the idea.
33B:540
31Frame 540 OP
32The placement of the "increment" operator (either before or after the
32variable) has no effect on the outcome of statement execution.
32(True of false)
33N
34 Right.
34 B:545
35 Wrong.  variable++  and  ++variable will produce different results depending
35 on how and when they are used.
```

```
35 B:545
31Frame 545 T
32    * Decrement Operator *
32
32    In the statement:  y_value = y_value - 1;  the value of y_value is
32    decremented by 1 and restored in the memory location identified by
32    the variable "y_value".  This is a valid statement in C, but again
32    C has a shorthand way of doing the same thing.  In this shorthand
32    notation, the statement would be written as  y_value--;  Thus:
32
32    y_value = y_value - 1;   and   y_value--;  are equivalent statements.
32
32    The above example again demonstrates the use of "postfix" notation.
32    The same result could have been obtained by using "prefix" notation.
32    If you were to use the statement:  --y_value;  the stored value of
32    "y_value" would have been decremented by 1 as it was using the other
32    two statements.  Let's again look at an example showing the difference
32    between using "prefix" and "postfix" notation.
33B:550
31Frame 550 T
32    * Decrement Operator Continued *
32
32    If we assign the value of 15 to the variable "y_value" using the
32    statement:  y_value = 15;  and then preform some arithmetic operation
32    using the variable "y_value" and the decrement operator, what would be
32    the result?
32
32    Well, again it all depends on whether you use "prefix" or "postfix"
32    notation.
32
32    If we preform the statement:  Answer = --y_value;  then the value
32    stored in "Answer" is 14, and "y_value" is decremented to 14, but
32    if we preform the statement:  Answer = y_value--;  then the value
32    stored in "Answer" is 15, and "y_value" is decremented to 14.
32
32    Remember:  prefix - value taken second, postfix - value taken first.
33B:555
31Frame 555 QM
32Which of the following represents the contents of variables "Answer" and
32"y_value" after execution of the statement:  Answer = 25 + (--y_value);
32given the initial value of "y_value" is 10?
33A+ Answer = 16  and  y_value = 9
33
33B  Answer = 15  and  y_value = 9
33
33C  Answer = 16  and  y_value = 10
33
33D  Answer = 15  and  y_value = 10
34 You are correct.
34 B:560
35BCD Wrong.  Choice "A" is correct.
35 B:560
```

```
35E I'm sorry, "E" was not one of your choices.
35 B:555
31Frame 560 T
32    *** Assignment Operators ***
32
32    The assignment operators are represented by the following:
32
32    Equal (=), and Operation equal (op=), where the "operation" is one of
32    the binary operators.
32
32    We have already seen how the first assignment operator is used.
32    As an example we have a statement such as:  Answer = 25;
32
32    In this example, the equal assignment operator is used to place the
32    value of 25 in the memory location represented by the variable "Answer".
32    This assignment is done "right to left", so it is possible to make
32    several assignments using one statement.  For example:
32
32    a_val = b_val = c_val = 0;  will set all the named variables to zero.
33B:565
31Frame 565 T
32    * Assignment Operators Continued *
32
32    The "operation equal" operators are really nothing more than a short-
32    hand method of writing a statement that involves doing some operation
32    on a variable and storing the result back into that variable's memory
32    location.  For example, in the statement:
32
32    x_value = x_value + 25;  25 is added to the value of x_value and the
32    result is stored in the memory location represented by x_value.
32
32    C provides a way to accomplish this in a shorter statement (although
32    the one above is also valid).  An equivalent C statement would be:
32
32    x_value += 25;
32
32    All operations on the right will be done before the operation identi-
32    fied in front of the "=" sign.
33B:570
31Frame 570 T
32    * Assignment Operators Continued *
32
32    That last statement is an important one.  For example, in the statement
32
32    a_val *= b_val + c_val;  you will get a different result if the
32    statement were evaluated as:  a_val = (a_val * b_val) + c_val;
32    To eliminate this problem, C will evaluate the statement according
32    to the following rule:
32
32    left_variable = (left_variable) "op" (right_expression);
32
32    Our example will be evaluated as:  a_val = (a_val) * (b_val + c_val);
```

```
33B:575
31Frame 575 QP
32The result stored in "x_value" after execution of the statement:
32x_value -= 35 + 20;  given an initial value for "x_value" of 100,
32would be 45.  (True or False)
33Y
34 Right.
34 B:580
35 Worng.
35 B:580
31Frame 580 T
32    *** Topic Summary ***
32
32    In this topic area we have looked at a description and examples of
32    arithmetic, increment & decrement, and assignment operators.
32
32    In the next topic area we will continue our discussion of operators
32    and expressions and their use in C.
32
32
32                  *** This concludes this topic area. ***
33END
41Frame 700 T  OPERATORS & EXPRESSIONS II
42    *** Introduction ***
42
42    In this topic area we will be continue discussing the use of operators
42    in expressions that we started in the last topic area.
42
42    This second topic area on this subject will cover the following:
42
42    1. Relational Operators
42    2. Logical Operators
42    3. Bitwise Logical Operators
42    4. Negation Operator
42    5. Conditional Operator
42
42
42    Let's get started ...
43B:705
41Frame 705 T
42    *** Relational Operators ***
42
42    Relational operators are used within a program in order to compare
42    one or more data values.  The relational operators are represented
42    by the following:
42
42    Equality (==), Inequality (!=), Greater than (>), Greater than or
42    equal to (>=), Less than (<), and Less than or equal to (<=).
42
42    Expressions involving these operators are evaluated as being either
42    "true" or "false".  If an expression is "true" then the expression
42    has a value of 1 (one), if it is "false" than the value is 0 (zero).
```

```
42
42    Let's take a look at an example to help make this clear.
43B:710
41Frame 710 T
42    * Relational Operators Continued *
42
42    For our example let's compare two variables:
42
42    var_1 >= var_2  is an expression that has a value of either "true"
42    or "false".  If var_1 is indeed greater than or equal to var_2, then
42    the expression is "true" and has a value of 1 (one).  Likewise, if
42    var_1 is not greater than or equal to var_2, then the expression is
42    "false" and has a value of 0 (zero).
42
42    In order to give this evaluation meaning, it must be somehow used in
42    a valid C statement.  An easy to understand example is:
42
42    var_flag = (var_1 >= var_2);
42
42    "var_flag" will be assigned either 1 or 0 depending on the evaluation
42    of the expression:  var_1 >= var_2
43B:715
41Frame 715 T
42    * Relational Operators Continued *
42
42    The example we looked at was one in which a comparison was made between
42    two variables.  This is not the only way to use the relational operators
42    as you can well imagine.
42
42    Some of the more common situations that relational operators are used
42    in include:  comparing array values, checking for "end of file",
42    controlling function calls, and controlling statement execution.
42
42    Relational operators have a lower precedence than arithmetic operators,
42    and assignment operators have lower precedence than relational operators
42    thus, the statement:  val_one = val_2 != val_3 - 5;  will be evaluated
42    as:  val_one = (val_2 != (val_3 - 5));  The final value of either 1 or
42    0 will eventually be stored in the memory location represented by the
42    variable "val_one".
43B:720
41Frame 720 QM
42Which of the following is "not" a relational operator?
43A  ==
43
43B  !=
43
43C  >=
43
43D  <
43
43E+ ++
44 Right.
```

```
44 B:725
45ABCD Wrong.  That is one of the relational operators, choice "E" is not.
45 B:725
41Frame 725 T
42    *** Logical Operators ***
42
42    Logical operators are also called logical connectives and they are
42    used to combine expressions being used for comparison.  The logical
42    operators are represented by the following:
42
42    Logical AND (&&)     and     Logical OR (||)
42
42    Expressions involving these operators are evaluated as being either
42    "true" or "false".  If an expression is "true" then the expression
42    has a value of 1 (one), if it is "false" than the value is 0 (zero).
42
42    Let's take a look at an example.
43B:730
41Frame 730 T
42    * Logical Operators Continued *
42
42    In the expression:  in_char == 'y' || in_char == 'n', the value of the
42    expression can once again have a value of either 1 or 0 depending on
42    whether the expression is "true" or "false".
42
42    In order to give this evaluation meaning, it must be somehow used in
42    a valid C statement.  An example is:
42
42    valid_resp = (in_char == 'y' || in_char == 'n');
42
42    "valid_resp" will be assigned either 1 or 0 depending on the evaluation
42    of the expression:  in_char == 'y' || in_char == 'n'
42
42    In other words, valid_resp will be 1 if in_char equals either y OR n,
42    or 0 if in_char equals anything else.
43B:735
41Frame 735 T
42    * Logical Operators Continued *
42
42    Logical operators have a lower precedence than relational operators,
42    and assignment operators have lower precedence than logical operators
42    thus, the statement:
42
42    result_val = val_1 < val_2 && val_3 != val_4;
42
42    is evaluated as:  result_val = ((val_1 < val_2) && (val_3 != val_4));
42
42    The final value of either 1 or 0 will eventually be stored in the
42    memory location represented by the variable "result_val".
43B:740
41Frame 740 QP
42In the statement:  True_Response = choice == 't' || choice == 'T';
```

```
42the value of "True_Response" will be set to 1, only if both "choice == 't'"
42and "choice == 'T'" are true.  (True or False)
43N
44 That's right.
44 B:745
45 Wrong.  Only one of the expressions has to be true when using the "OR"
45 logical operator.
45 B:745
41Frame 745 T
42    *** Bitwise Logical Operators ***
42
42    The use of bitwise logical operators is beyond the scope of this
42    course.  However, I feel that their existence should be mentioned.
42
42    Bitwise logical operators are represented by the following:
42
42    Bitwise AND:  &
42    Bitwise inclusive OR:  |
42    Bitwise exclusive OR:  ^
42    Left shift:  <<
42    Right shift:  >>
42    Unary one's complement:  ~
43B:750
41Frame 750 T
42    *** Negation Operator ***
42
42    The negation operator is a unary NOT operator.  It is used to convert
42    or reverse the value of the operand it appears in front of.
42
42    The exclamation point (!) is used for this operator.
42
42    For example, in the expression:  !(val_one < 30)  if the value of the
42    inner expression is "true" then the value of the entire expression is
42    "false", and vice versa.
42
42    The parentheses, in this case, are necessary since the negation oper-
42    ator has a higher precedence than relational operators.
42
42    A statement using the negation operator would look something like this:
42
42    control_flag = ! found_flag;
43B:755
41Frame 755 T
42    *** Conditional Operator ***
42
42    The conditional operator is what is called a "ternary" operator.
42
42    What this means is that the operator acts upon three operands.  The
42    effect it has is very similar to an "if-else" control statement.
42
42    The conditional operator is represented by a question mark and colon.
43B:760
```

```
41Frame 760 T
42    *** Conditional Operator Continued ***
42
42    For example, in the statement:
42
42    new_val = val_1 == 1 ? new_val = 25 : new_val = 30;
42
42    The final value of "new_val" depends on the value of "val_1".  If
42    val_1 is equal to 1, then the expression "val_1 == 1" is true and
42    the expression "new_val = 25" will be executed, else if "val_1 == 1"
42    is false, then the expression "new_val = 30" will be executed.  The
42    value of new_val will be stored in the memory location represented
42    by the variable "new_val" because of the assignment operator "="
42    after the variable "new_val" on the left side of the statement.
43B:765
41Frame 765 QP
42In the statement:  val_1 = test_val ? val_1 = 1 : val_1 = 0;
42if test_val equals 1, then the value of val_1 will be 1.  (True or False)
43Y
44 Right.
44 B:770
45 Wrong.  "val_1 = 1" would be executed, thus setting "val_1" equal to 1.
45 B:770
41Frame 770 T
42    *** Lesson Two Summary ***
42
42    Well, that about does it for lesson number two.  If you have seen the
42    four subject topics in this lesson, you should now be ready to take
42    the final test.  If you feel that you don't understand something well
42    enough to pass the test, please retake the topic that is giving you
42    problems.
42
42    Topic #  !------------------- Subject covered ----------------------!
42
42       1     Character & interger constants and variables.
42
42       2     Real & double precision real constants and variables.
42
42       3     Arithmetic, increment & decrement, and assignment operators.
42
42       4     Relational, logical, negation, and conditional operators.
43END
51Frame 900 TT TEST OVER LESSON 2
52    Welcome to the final test of lesson two.  This test consists of ten
52    questions over material presented in the previous four topic areas.
52
52    In order to successfully complete this lesson, you must achieve a
52    minimum score of 70% (seven out of ten questions correct).
52
52    If you miss a question, the correct answer will not be shown.  It is
52    up to you to research the correct answer.
52
```

```
52    Well, enough said.  Let's get on with it.  Good luck!
53B:905
51Frame 905 QM
521.  Which of the following is not a valid variable name?
53A  x1_y2
53
53B+ int
53
53C  _IN_
53
53D  var
54 Right.      (1,105)
54 B:910
55ACD Wrong.      (1,105)
55 B:910
55E "E" was not one of your choices.
55 B:905
51Frame 910 QP
522.  A character constant is symbolized as a single character enclosed
52within single quotation marks.  (True or False)
53Y
54 Right.      (1,120)
54 B:915
55 Wrong.      (1,120)
55 B:915
51Frame 915 QM
523.  Which one of the following characters is used to identify a special
52character escape sequence?
53A  #
53
53B  +
53
53C+ \
53
53D  %
54 Right.      (1,130)
54 B:920
55ABD Wrong.      (1,130)
55 B:920
55E "E" was not one of your choices.
55 B:915
51Frame 920 QP
524.  In the statement:  double var_one = 358.8204;  the keyword "double" is
52used to indicate that variable "var_one" is to be doubled in value before
52being stored in the memory location represented by "var_one".
52(True or False)
53N
54 Right.      (2,315)
54 B:925
55 Wrong.      (2,315)
55 B:925
51Frame 925 QM
```

```
525.  Which of the following is "not" an arithmetic operator?
53A  +
53
53B  *
53
53C  /
53
53D+ =
54 Right.      (3,505)
54 B:930
55ABC Wrong.      (3,505)
55 B:930
55E "E" was not one of your choices.
55 B:925
51Frame 930 QM
526.  Which of the following is the value that will be assigned to the variable
52"Answer" after execution of the statement:  Answer = 22 % 5;
53A+ 2
53
53B  4.4
53
53C  4
53
53D  .4
54 Right.      (3,510)
54 B:935
55BCD Wrong.      (3,510)
55 B:935
55E "E" was not one of your choices.
55 B:930
51Frame 935 QP
527.  The placement of the "increment" (++) or decrement (--) operators, with
52respect to the variable they operate on, never has an effect on the outcome
52of statement execution.
53N
54 Right.      (3,530 & 545)
54 B:940
55 Wrong.      (3,530 & 545)
55 B:940
51Frame 940 QP
528.  The result stored in "Answer" after execution of the statement:
52Answer *= 10 + 10;  given an initial value for "Answer" of 10,
52would be 220.  (True or False)
53N
54 Right.      (3,555)
54 B:945
55 Wrong.      (3,555)
55 B:945
51Frame 945 QM
529.  Which of the following is "not" a relational operator?
53A  >=
53
```

```
53B  <=
53
53C  ==
53
53D+ +=
54 Right.      (4,705)
54 B:950
55ABC Wrong.      (4,705)
55 B:950
55E "E" was not one of your choices.
55 B:945
51Frame 950 QM
5210.  Which of the following represent the logical operators "OR" and "AND"?
53A  || and ~
53
53B  ~ and &&
53
53C  ## and ||
53
53D+ || and &&
53
53E  @@ and ++
54 Right.      (4,720)
54 B:955
55ABCE Wrong.      (4,720)
55 B:955
51Frame 955 T
52    *** End of Lesson Material ***
52
52    This marks the end of lesson number two.  I hope that it was of some
52    benefit to you.  I am looking forward to seeing you in lesson number
52    three.  I hope that you didn't have too much trouble with the material
52    presented in this lesson.  If you did, please voice your comments to
52    your training monitor who will in turn contact the CAI Plans Branch
52    at Keesler AFB, MS.
52
52    Well, let's take a look at how you did with the test ...
53END
```

File "LESSON3"

```
#     WW     WW  EEEEEEEE  LL          CCCCCCC   OOOOOO   MMM  MMM  EEEEEEEE
#     WW WW WW  EE        LL        CC         OO    OO  MMM  MMM  EE
#     WW WW WW  EEEEE     LL        CC         OO    OO  MM MM MM  EEEEE
#     WWW  WWW  EE        LL        CC         OO    OO  MM MM MM  EE
#     WWW  WWW  EEEEEEEE  LLLLLLLL   CCCCCCC   OOOOOO   MM    MM  EEEEEEEE
#
#
#                          TTTTTTTTTT    OOOOOOOO
#                              TT       OO      OO
#                              TT       OO      OO
#                              TT       OO      OO
#                              TT        OOOOOOOO
#
#
#     LL         EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN     3333333
#     LL         EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NNN   NN    33333333
#     LL         EE        SSS       SSS       OO    OO  NNNN  NN         33
#     LL         EEEEE      SSSS      SSSS     OO    OO  NN NN NN       333
#     LL         EEEEE        SSSS      SSSS   OO    OO  NN NN NN         33
#     LL         EE             SSS       SSS  OO    OO  NN  NNNN   3     33
#     LLLLLLLL   EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NN   NNN   33333333
#     LLLLLLLL   EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN    333333
#
#  THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INFORMATION ON PROGRAM CONTROL
#  STATEMENTS USED IN THE  C  PROGRAMMING LANGUAGE.
#
#  THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.
#
#
#  The Lesson Breakdown Is As Follows:
#
#  Topic 1:  If, If-Else, Nesting, and Switch - This topic gives descriptions
#            of the structure and use of the If and If-Else control statements
#            and how to "nest" these statements.  Also covered in this topic
#            is the Switch control structure.  (Approx. time = 15 min.)
#
#
#  Topic 2:  Loops (While, For, and Do-While) - This topic discusses the struc-
#            ture and use of loop statements.  (Approx. time = 15 min.)
#
#
#  Topic 3:  Break and Continue Statements - This topic gives a description of
#            the Break and Continue statements and how and when they are used.
#            (Approx. time = 10 min.)
#
#  Lesson Breakdown Continued:
#
#  Topic 4:  Goto statement and Labels - This topic gives a description of the
#            Goto statement and the use of labels within a C program.
#            (Approx. time = 5 min.)
```

```
#
#
#  Topic 5:  Lesson 3 Test - This is the lesson test over items that have
#            been presented in the previous four lesson topics.
#            (Approx. time = 5 min.)
#
#
#  TOTAL LESSON TIME IS APPROXIMATELY 50 MINUTES.
#
#
#  I hope that you enjoy it!
!
*****************************************************************************
*                                                                           *
*              SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:        *
*                                                                           *
*****************************************************************************
*                                                                           *
*     STATUS          TOPIC #          TOPIC TITLE                          *
*     ------          -------          -----------                          *
*                                                                           *
@                       1              If, If-Else, Nesting, and Switch     *
*                                                                           *
@                       2              Loops (While, For, and Do-While)     *
*                                                                           *
@                       3              Break and Continue Statements        *
*                                                                           *
@                       4              Goto statement and Labels            *
*                                                                           *
@                       5              Test Over Lesson 3                   *
*                                                                           *
*****************************************************************************
*      NOTE:  A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.     *
*****************************************************************************
11Frame 100 T  IF, IF-ELSE, NESTING, SWITCH
12    *** Control Statements ***
12
12    Control statements are used in programming languages to provide a
12    means of altering the "normal" flow of the program.
12
12    Without the use of control statements, program execution would proceed
12    in a sequential fashion starting with the first executable statement
12    and ending with the last executable statement.  In most cases this is
12    not the desired way in which the programmer wants the program to exe-
12    cute.  Thus, the need and capability for imposing control over program
12    execution using program control statements.
12
12    The control statements that we will be looking at in this topic are
12    the "if", "if-else", and "switch".  We will also cover "nesting" of
12    "if" statements.
12
12    Let's get started.
```

```
13B:105
11Frame 105 T
12    *** If Statement ***
12
12    The "if" statement is used to control the execution of a statement or
12    statements by testing an expression.  The expression is checked to see
12    if it is "true" (non zero) or "false" (zero).  If the statement is in-
12    deed "true", then the statement (or statements) following the "if" is
12    executed.  If the expression is "false", then the next sequential
12    statement is executed.
12
12    The structure of the basic "if" statement is as follows:
12
12    if(test_expression)
12       statement_to_be_executed;
12
12    next_sequential_statement;
12
12    Let's take a look at an actual example of the basic "if" statement.
13B:110
11Frame 110 T
12    * If Statement Continued *
12
12    For this example let tax_val, high_tax, and tax_rate be of type "int".
12
12    if(tax_val >= 10)
12       high_tax++;
12
12    tax_rate = tax_val / 100;
12
12    In this example, the expression "tax_val >= 10" is tested.  If the
12    value of "tax_val" is greater than or equal to 10, then the statement
12    "high_tax++;" is executed, otherwise program execution continues with
12    the statement "tax_rate = tax_val / 100;"
12
12    By now you should be asking yourself:  "How does the compiler know what
12    statement is associated with the 'if' statement?"  The answer of course
12    is quite simple.  Let's clear up the question and expand the "if".
13B:115
11Frame 115 T
12    * If Statement Continued *
12
12    The example we just looked at could just as easily have been written as:
12
12    if(tax_val >= 10)
12    high_tax++;
12    tax_rate = tax_val / 100;
12
12    This is confusing to the programmer, but not to the compiler.  When
12    the "if" statement is encountered, the next sequential statement is
12    the only one that is associated with it.  Therefore, only "high_tax++;"
12    is subject to conditional execution.  The statement "tax_rate = tax_val
```

```
12    / 100;" will be executed no matter what the result of the "if" test is.
12
12    This brings up the question of how do we provide for the execution of
12    several statements after the "if" statement?  Let's take a look.
13B:120
11Frame 120 T
12    * If Statement Continued *
12
12    If it is desired to have a group of statement's execution controlled
12    by an "if" statement, then you must use braces "{}" to form a "block"
12    of one or more statements to be conditionally executed.  For example:
12
12    if(test_expression)
12       {
12        first_statement;
12        second_statement;
12                .
12                .
12                .
12        last_statement;
12       }
12
12    next_sequential_statement;
13B:125
11Frame 125 QM
12Which of the following is used to "block" statements into a group to be
12conditionally executed?
13A  ( )
13
13B  [ ]
13
13C+ { }
13
13D  | |
14 Correct.
14 B:130
15ABD Wrong.  Choice "C" is correct.
15 B:130
15E I'm sorry, "E" was not one of your choices.
15 B:125
11Frame 130 T
12    *** If-Else Control Structure ***
12
12    An option to the "if" statement is the use of an "else".
12
12    I will use the same example as before to illustrate the structure and
12    use of the "if-else" control structure.
12
12    if(tax_val >= 10)
12       high_tax++;
12    else
12       low_tax++;
```

```
12    tax_rate = tax_val / 100;
12
12    Here, the expression "tax_val >= 10" is tested.  If the value of the
12    "tax_val" is greater than or equal to 10, then "high_tax++;" is execu-
12    ted, otherwise "low_tax++;" is executed before execution continues with
12    the statement "tax_rate = tax_val / 100;"
13B:135
11Frame 135 T
12    * If-Else Control Structure Continued *
12
12    Of course you may use a "block" of statements after either or both the
12    "if" or "else" parts of the control structure.  For example:
12
12    if(test_expression)
12       {
12        statement_1;
12        statement_2;
12       }
12    else
12       {
12        alt_statement_1;
12        alt_statement_2;
12        statement_3;
12       }
12    next_sequential_statement;
13B:140
11Frame 140 T
12    * If-Else Control Structure Continued *
12
12    It is often the case that you may need to test more than one expres-
12    sion within an "if-else" structure.  This may be done by using what
12    is called a multi-way decision structure.  I will show you one way
12    to do this using the "if-else" structure now, and later we will see
12    another way using the "switch" structure.  Using "if-else" structure:
12
12    if(tax_val >= 10)              ;  Using this structure, one of the
12       high_tax++;                 ;  variables:  "high_tax", "low_tax",
12    else if(tax_val <=5)           ;  or "medium_tax" will get incremented
12       low_tax++;                  ;  depending on the value of "tax_val".
12    else                           ;  If you didn't want to keep track of
12       medium_tax++;               ;  "medium_tax", you could leave off
12    tax_rate = tax_val / 100;      ;  the last else and its statement.
13B:145
11Frame 145 QP
12When using the "if-else" control structure, you are limited to only one
12executable statement for each part of the structure.  (True or False)
13N
14 Right.  "Blocks" of statements can be defined by the use of braces "{}".
14 B:150
15 Wrong.  "Blocks" of statements can be defined by the use of braces "{}".
15 B:150
11Frame 150 T
```

```
12    *** Nesting ***
12
12    Another capability of the "if-else" structure is being able to "nest"
12    other "if" or "if-else" structures within the original "if-else".
12    For example:
12
12    if(test_exp_1)              ¦  In this structure, if "test_exp_1" is true
12       if(test_exp_2)           ¦  then "test_exp_2" is checked and if found
12          statement_one;        ¦  true, then "statement_one" is executed if
12       else                     ¦  however, "test_exp_2" is false, then the
12          alt_statement_one;    ¦  "alt_statement_one" is executed.  If the
12    else                        ¦  "test_exp_1" was found to be false, then
12       statement_two;           ¦  only "statement_two" would be executed.
12    next_seq_statement;         ¦
12
12    Note:  True is any "non zero" value and false is a "zero" value.
12           Also, "blocks" of statements can be used in the structure.
13B:155
11Frame 155 T
12    * Nesting Continued *
12
12    Caution must be exercised when nesting "if-else" structures.  Remember,
12    the "else" part of the "if-else" structure is optional.  Thus, it is
12    fairly easy to have an "else" apply to the wrong "if" statement.
12    Let's take a look at an example to show how this can happen.
12
12    For our example, let's say we want to check an expression and if it is
12    true, then we want to check a second expression and if it is true, then
12    we want to execute a statement, but if the second expression is false,
12    we don't want any statement executed.  If however, our first expression
12    is false, then we want to execute a different statement.  How would we
12    code such a thing?  Well, let's give it a try.
13B:160
11Frame 160 T
12    * Nesting Continued *
12
12    At first glance the following seems to do what was described.
12
12    if(test_exp_1)
12       if(test_exp_2)
12          statement_one;
12    else
12       statement_two;
12
12    Even though I indented the code to look like the "else" goes with the
12    first "if", it really goes with the last "if" that doesn't have an
12    "else".  Thus, the above code doesn't solve the problem as I stated it.
13B:165
11Frame 165 T
12    * Nesting Continued *
12
12    In order to solve the stated problem, we must use brases to force
```

```
12    program execution.
12
12    Compare the code I gave before (left) to the correct code (right).
12
12    if(test_exp_1)                  |    if(test_exp_1)
12       if(test_exp_2)               |       {
12          statement_one;            |        if(test_exp_2)
12    else                            |           statement_one;
12       statement_two;               |       }
12                                    |    else
12                                    |       statement_two;
12
12    As you can see, the execution of the code is greatly affected by the
12    placement of the braces in the "if-else" control structure.
13B:170
11Frame 170 QM
12Given:  if(x > 0)
12           if(x > 10)
12              x_large = 1;
12           else
12              x_small = 1;
12        else
12           if(x == 0)
12              x_zero = 1;
12
12Which of the following would be true if x = -1 ?
13A  x_large would be set to 1
13B  x_small would be set to 1
13C  x_zero would be set to 1
13D+ none of the above
13E  A, B, and C would be true
14 Very good.
14 B:175
15ABCE Wrong.  All expressions would be false, therefore no statements would
15 be executed.
15 B:175
11Frame 175 T
12    *** Switch Statement ***
12
12    We saw earlier that one way to do multi-way decisions was with the use
12    of several "if-else" statements linked together.
12
12    A common use of such a structure is when you test a variable and depend-
12    ing on its value (as compared to a constant) a statement or group of
12    statements is executed.  For example:
12
12    if(test_var == 10)
12       statement_to_be_executed;
12    else if (test_var == 15)
12             alt1_statement_to_be_executed;
12    else if (test_var == 20)
12             alt2_statement_to_be_executed;
```

```
12    else
12       default_statement_to_be_executed;
13B:180
11Frame 180 T
12    * Switch Statement Continued *
12
12    In the example, we saw how to use the "if-else" structure to accomplish
12    the testing of one variable and execution of different statements depen-
12    ding on the value of the variable.
12
12    Well, in C we have another way to accomplish the same thing.  We can
12    use the "switch" statement.  In the "switch" statement each constant
12    value we wish to test the variable against is labeled with the keyword
12    "case".  The last statement (following the last "else" in our example)
12    is labeled with the keyword "default".
12
12    Let's take a look at our example again, but this time we will use the
12    "switch" statement structure.
13B:185
11Frame 185 T
12    * Switch Statement Continued *
12
12    switch(test_var)  {                              ! Note:  "test_var" must
12       case 10:                                      ! evaluate to type "int",
12             statement_to_be_executed;               ! braces are used, colons
12             break;                                  ! are used after each case
12       case 15:                                      ! constant (constant ex-
12             alt1_statement_to_be_executed;          ! pression), "break" is
12             break;                                  ! discussed in topic 3 of
12       case 20:                                      ! this lesson, "break" &
12             alt2_statement_to_be_executed;          ! "default" are optional,
12             break;                                  ! the final semicolon is
12       default:                                      ! required since "switch"
12             default_statement_to_be_executed;       ! is really just a "block"
12             break;                                  ! type statement, and the
12    };                                               ! order of cases/default
12                                                     ! is arbitrary.
13B:190
11Frame 190 QP
12Essentially, the "switch" is just a special case of the "if-else" structure,
12and its use is really just "programmer preference".  (True or False)
13Y
14 Right.  You can do the same thing using the "if-else" structure.
14 B:195
15 Wrong.  You can do the same thing using the "if-else" structure.
15 B:195
11Frame 195 T
12    *** Topic Review ***
12
12    In this topic we have looked at the "if" statement, the "if-else" struc-
12    ture, nesting of the "if-else" structure, and the "switch" statement.
12
```

```
12    We have seen many examples of what these statements and structures look
12    like, and how they are used.
12
12    In the next topic area I will describe and show examples of loop state-
12    ments and structures.
12
12    See you there!
12
12
12                    *** This concludes this topic area. ***
13END
21Frame 300 T  LOOPS (WHILE, FOR, DO-WHILE)
22    *** Loops ***
22
22    Loops are used in programming languages to provide a way of repeatedly
22    executing a statement or group of statements within the program.
22
22    The way in which a loop is written can vary.  The most common reason
22    for this variability is again "programmer preference".  Most, if not
22    all, loops can be written using only one of the structures that we
22    will be covering in this topic area.
22
22    The loop control statements and structures that we will be looking at
22    in this topic are the "While", "For", and "Do-While".
22
22    Let's get started.
23B:305
21Frame 305 T
22    *** While Loop ***
22
22    The "while" loop is a two part control structure.  The first part is
22    the loop control expression, and the second part is the executable
22    body.
22
22    The loop control expression is a expression that is tested at the be-
22    ginning of the loop and after execution of the body.  The loop control
22    expression is "true" whenever it is "non zero" and "false" when it is
22    "zero".  Execution of the body will continue until the control expres-
22    sion is "false".  If the expression is "false" the first time, then
22    program control will drop to the next sequential program statement.
22
22    The structure of the "while" loop looks like this:
22
22    while (test_expression)          ;  Of course, braces can be used to
22       statement_to_be_executed;     ;  define a "block" of statements.
23B:310
21Frame 310 T
22    * While Loop Continued *
22
22    Here is an example using the "while" loop control statement:
22
22    sum = 0;
```

```
22    loop_var = 0;
22    while (loop_var == 0)  {
22       if(sum < 10)
22          sum += 2;
22       else
22          loop_var++;
22    }
22
22    When the "while" is encountered, the test expression is checked and
22    found to be "true", so the loop body is then executed.  Execution of
22    the loop body will continue until the loop control expression is no
22    longer true.  That will occur, in this example, after 6 iterations.
23B:315
21Frame 315 QP
22If the loop control expression is "false" the first time it is checked, then
22the loop body will be executed only once before program control drops to the
22next sequential program statement after the "while" loop.  (True or False)
23N
24 That's right.  The loop body will be skipped entirely.
24 B:320
25 Wrong.  The loop body will be skipped entirely.
25 B:320
21Frame 320 T
22    *** For Loop ***
22
22    The "for" loop is a three part control structure.  The first part is
22    the loop control initialize expression, the second part is the loop
22    control test expression, and the third part is the loop control incre-
22    ment expression.
22
22    The loop control initialize expression is a expression that is evalu-
22    ated once and can serve to initialize variables used within the loop
22    body.  The loop control test expression is tested at the beginning of
22    the loop and after execution of the body.  Again, the loop control ex-
22    pression is "true" whenever it is "non zero" and "false" when it is
22    "zero".  Execution of the body will continue until the control expres-
22    sion is "false".  If the expression is "false" the first time, then
22    program control will drop to the next sequential program statement.
22    The loop control increment expression is evaluated after execution of
22    the loop body.
23B:325
21Frame 325 T
22    * For Loop Continued *
22
22    The structure of the "for" loop looks like this:
22
22    for (initialize_exp; test_exp; increment_exp)
22       statement_to_be_executed;
22
22    Again, the braces can be used to define a "block" of statements.
22    Such as:
22
```

```
22    for (loop_var = 0; loop_var < 50; loop_var++)  {
22       first_statement;
22       next_statement;
22       last_statement;
22    }
23B:330
21Frame 330 T
22    * For Loop Continued *
22
22    Here is an example using the "for" loop control statement:
22
22    for (i = 0; i < 20; i++)
22       if((i % 2) == 0)
22          printf("i value is even");
22       else
22          printf("i value is odd");
22
22    When the "for" is encountered, the loop control initialize expression
22    is executed setting i equal to zero.  Next the loop control test ex-
22    pression is checked and found to be "true", so the loop body is then
22    executed.  After execution of the loop body the loop control increment
22    expression is executed settint i equal to i plus one.  The loop control
22    test expression is then checked again.  The execution of the loop body
22    will continue until the loop control expression is no longer "true".
23B:335
21Frame 335 QM
22Which of the following is "not" a part of the "for" loop control structure?
23A  initialize expression
23
23B  test expression
23
23C+ terminate expression
23
23D  increment expression
24 Correct.  Keep up the good work.
24 B:340
25ABD No.  The loop structure has that as one of its parts.
25 B:340
25E I'm sorry, "E" was not one of your choices.
25 B:335
21Frame 340 T
22    * For Loop Continued *
22
22    As I mentioned before, loop structures serve basically the same purpose
22    and can usually be accomplished by using one such structure.  We have
22    looked at both "while" and "for" loops so far.  Let's compare the struc-
22    ture of these two loop types.
22
22    The "while" structure:          |  The "for" structure:
22                                    |
22    init_exp;                       |  for (init_exp; test_exp; incr_exp)
22    while (test_exp)  {             |     statement_to_be_executed;
```

```
22       statement_to_be_executed;     ¦
22       incr_exp;                     ¦
22    }                                ¦
22
22    Which of these two structures you use is up to you, but there are times
22    when one may be more appropriate than the other.
23B:345
21Frame 345 T
22    *** Do-While Loop ***
22
22    The final loop structure available in C is the "do-while".
22
22    The "do-while" loop is a two part control structure just like the "do"
22    loop.  The basic difference between the "do" loop and the "do-while"
22    loop is that the first part of the "do-while" is the executable body,
22    and the second part is the loop control expression.  This is just the
22    opposite of the "do" loop control structure.
22
22    The loop body will be executed once, before the loop control expression
22    is tested at the end of the loop.  If the loop control expression is
22    "true" then the loop body will be executed again.  Execution of the loop
22    body will continue until the loop control expression is "false".  The
22    biggest difference, I'm sure you have noticed, is that the loop body
22    will be executed at least one time before program control drops to the
22    next sequential program statement.
23B:350
21Frame 350 T
22    * Do-While Loop Continued *
22
22    The structure of the "do-while" loop looks like this:
22
22    do
22       statement_to_be_executed;
22    while (test_expression);
22
22    Of course, braces can be used to define a "block" of statements.
22    It is suggested that you use braces at all times in order to avoid
22    the confusion caused by the "while" statement at the end of the loop.
22    It tends to look like the start of a "while" loop.  The following the
22    prefered format:
22
22    do {
22       statement_to_be_executed;
22    } while (test_expression);
23B:355
21Frame 355 QP
22The major difference between the "while" loop and the "do-while" loop is that
22the "do-while" will always be executed at least once whereas the "while" loop
22may be skipped altogether if the loop control expression is "false".
22(True or False)
23Y
24 Right.
```

```
24 B:360
25 Wrong.  That is a true statement.
25 B:360
21Frame 360 T
22    *** Topic Review ***
22
22    In this topic we have looked at the "while", "for", and "do-while"
22    loops.
22
22    We have seen many examples of what these statements and structures
22    look like, and how they are used.
22
22    In the next topic area I will describe and show examples of the
22    "break" and "continue" statements.
22
22    Hope I see you there!
22
22
22                  *** This concludes this topic area. ***
23END
31Frame 500 T  BREAK AND CONTINUE STATEMENTS
32    *** Break Statement ***
32
32    The "break" statement is used to terminate a "while", "for", or the
32    "do-while" loop before the loop control expression becomes "false".
32    It is also used in the "switch" control statement to prevent further
32    statement execution after a "case" has been found that satisfies the
32    switch.
32
32    When a "break" statement is encountered, it is executed and the loop
32    or case in which it is located is terminated immediately.  Program
32    control than passes to the next sequential statement following the
32    loop or switch.
32
32    I will show you how this looks in each of the loop structures as well
32    as the "switch" structure.
32
32    But first I want to be sure you want to see these examples.
33B:505
31Frame 505 QP
32Do you want to see examples of how the "break" statement is used?
32(Yes or No)
33Y
34 OK.  Here we go.
34 B:510
35 OK.  Let's take a look at the "Continue" statement.
35 B:535
31Frame 510 T
32    *** Break Statement Example #1:  "While" loop ***
32
32    The following is an example of how the "break" statement can be used in
32    the "while" loop.
```

```
32
32    exit = 0;                        ¦  Without getting into details of how the
32    while (exit == 0) {              ¦  "scanf" statement works or where you
32       scanf("%d", &in_int);         ¦  would use this section of code, this
32       if(in_int < 0)                ¦  example shows how the "break" statement
32          break;                     ¦  can be used to terminate the "while"
32       else                          ¦  loop before the loop control statement
32          sum += in_int;             ¦  becomes "false".  If the variable named
32       if(sum > 100)                 ¦  "in_int" ever becomes a negative number,
32          exit++;                    ¦  the "break" will be executed and program
32    }                                ¦  execution will continue with the next
32    next_sequential_statement;       ¦  sequential statement after the loop.
33B:515
31Frame 515 T
32    *** Break Statement Example #2:  "For" loop ***
32
32    The following is an example of how the "break" statement can be used in
32    the "for" loop.
32
32    for (i=0; i<=10; i++) {
32       in_char = getchar();
32       if(in_char = '.')
32          break;
32       last_name[i] = in_char;
32    }
32    next_sequential_statement;
32
32    Here, the loop will be terminated if "in_char" becomes a period (.) and
32    program execution will, once again, continue with the next sequential
32    statement after the loop.  Note:  We will cover "arrays" in lesson 4
32    and "input & output" in lesson 6.
33B:520
31Frame 520 T
32    *** Break Statement Example #3:  "Do-While" loop ***
32
32    The following is an example of how the "break" statement can be used in
32    the "do-while" loop.
32
32    count = 0;                                ¦  In this example, there are really
32    do {                                      ¦  two loop control expressions.  The
32       count++;                               ¦  loop would be terminated if the
32       if(count > 10)                         ¦  value of "count" becomes greater
32          break;                              ¦  than 10, or if variable "avg_num"
32       avg_num = (total / tot_num);           ¦  ever exceeds the value of 69.
32       scanf("%d", &in_int);                  ¦  Since the "do-while" is executed
32       tot_num++;                             ¦  before the loop control expression
32       total += in_int;                       ¦  is tested, the "break" statement
32    } while (avg_num < 70);                   ¦  could be used to control the loop's
32    next_sequential_statement;                ¦  execution the first time through.
33B:525
31Frame 525 T
32    *** Break Statement Example #4:  "Switch" statement ***
```

```
32
32    The following is an example of how the "break" statement is used in
32    the "switch" statement.
32
32    switch(temp) {          ¦  The "break" is used in the "switch" statement
32       case 70:             ¦  in order to prevent the unnecessary evalua-
32       case 80:             ¦  tion of expressions that will turn out to be
32              nice++;       ¦  "false".  The "break" statement will termin-
32              break;        ¦  ate the "switch" after the "case" is found
32       case 90:             ¦  that is "true" and the statement(s) is execu-
32              hot++;        ¦  ted.  It is important to note that the execu-
32              break;        ¦  tion of the switch is sequential, therefore
32       case 50:             ¦  if in our example the value of "temp" is 70,
32              cool++;       ¦  there is no need to check any "cases" after
32              break;        ¦  the execution of the statement "nice++;".
32    };                      ¦
33B:530
31Frame 530 QM
32Which of the following will the "break" statement "not" work with?
33A  "while" loop
33
33B  "for" loop
33
33C  "switch" statement
33
33D+ "if-else" statement
33
33E  "do-while" loop
34 Right you are.  The "if-else" works the same as the "switch" without the use
34 of the "break" statement.
34 B:535
35ABCE Wrong.  The "if-else" works the same as the "switch" without the use
35 of the "break" statement.
35 B:535
31Frame 535 T
32    *** Continue Statement ***
32
32    The "continue" statement is used within a loop structure in order to
32    force the loop's next iteration.  The "continue" is used with the
32    "while", "for", and "do-while" loops, but NOT with the "switch" state-
32    ment.
32
32    When you use the "continue" in the "while" and "do-while" loops, it
32    forces the immediate evaluation of the "loop control expression".
32
32    When you use the "continue" in the "for" loop, it executes the "loop
32    control increment expression" and then the "loop control expression"
32    is evaluated.
32
32    Let's take a look at an example.
33B:540
31Frame 540 T
```

```
32    * Continue Statement Continued *
32
32    The following is an example of the use of the "continue" statement in
32    a "for" loop.
32
32    for (i=0; i<max_i; i++) {
32       if(name_area[i] != ' ')
32          continue;
32       num_found++;
32    }
32
32    In this example the "continue" statement causes the loop to be executed
32    until a "space" is encountered or the "loop control test expression"
32    becomes "false".  Once a space is found, "num_found" is incremented,
32    the "loop control increment expression" is executed, and the "loop
32    control test expression" is evaluated.  Execution will continue in
32    this fashion until the "loop control test expression" becomes "false".
33B:545
31Frame 545 QP
32The use of the "continue" is only effective in the loop control structures
32of "while", "for", and "do-while".  (True or False)
33Y
34 Right.  It can be used in a "switch", but only if the switch is inside of
34 a loop structure, in which case it would cause the next iteration of the
34 loop structure.
34 B:550
35 Wrong.  It can be used in a "switch", but only if the switch is inside of
35 a loop structure, in which case it would cause the next iteration of the
35 loop structure.
35 B:550
31Frame 550 T
32    *** Topic Review ***
32
32    In this topic we have looked at the "break" and "continue" statements.
32
32    I have presented you the opportunity to see many examples of how the
32    "break" statement is used in the three different loop structures as
32    well as the "switch" statement.  You also saw an example of how the
32    "continue" statement can be used within a "loop" structure.
32
32    In the next topic area I will describe and show examples of the
32    "goto" and "label" statements.
32
32    Hope I see you there!
32
32
32                  *** This concludes this topic area. ***
33END
41Frame 700 T  GOTO STATEMENT AND LABELS
42    *** Introduction ***
42
42    The use of "goto" statements has come under attack within the software
```

```
42    engineering community of experts.  Although most languages provide for
42    the use of "goto", it is highly discouraged.  Most instances of the
42    statement can be eliminated by careful software development.  This is
42    especially true in a language such as C.
42
42    Even though use of the statement is discouraged, it is a part of the
42    language and therefore I will give a brief description of how it is
42    used.
43B:705
41Frame 705 T
42    *** Label Statement ***
42
42    In order to use the "goto" statement, you must have some way of identi-
42    fing where to "goto" to.  In other languages such as BASIC or Fortran,
42    this is done by using statement numbers.  C doesn't use statement num-
42    bers but instead uses "labels".
42
42    A label is declared in a function by using the following form:
42
42    label_name:
42
42    When naming a "label", follow the same rules that you use when naming
42    a variable.
42
43B:710
41Frame 710 T
42    *** Goto Statement ***
42
42    The "goto" statement is used to transfer program control to some point
42    within a function other than the next sequential statement.  The point
42    MUST be a labeled point in the same function.
42
42    The most common use of the "goto" statement is to terminate execution
42    of a deep nested loop structure.  As we learned in the last topic area,
42    we can use the "break" statement to terminate a loop but it will only
42    terminate the inner most loop (the one it is physically in).
42
42    A "goto" statement has the following form:  goto label_name;
42
42    Note: "goto" is one word.  The use of:  go to label_name;  will cause
42    a compile error.
43B:715
41Frame 715 T
42    *** Goto/Label Example ***
42
42    The following two sections of code provide an example of how the "goto"
42    statement is used in conjunction with a label and how to write the same
42    section without using a "goto" statement.
42
42    Code with the "goto" & "label"    |  Code without using the "goto"
42    ----------------------------------------------------------------------
42    in_out() {                        |  in_out() {
```

```
42       char c;                          |     char c;
42       begin:                           |     do {
42          c = getchar();                |         c = getchar();
42          if(c!='\n') {                 |         if(c!='\n')
42             printf("%c",c);            |            printf("%c",c);
42             goto begin; }              |     } while (c!='\n');
42       return;                          |     return;
42    }                                   |  }
43B:720
41Frame 720 QP
42You can only use the "goto" statement to transfer program control to a label
42within the function where the "goto" is located.  (True or False)
43Y
44 Right.
44 B:725
45 Wrong.  You can not transfer control to any other part of the program using
45 the "goto" statement.
45 B:725
41Frame 725 T
42    *** Lesson Three Summary ***
42
42    Well, we have come to the end of another lesson.  If you have seen the
42    four subject topics in this lesson, you should now be ready to take
42    the final test.  If you feel that you don't understand something well
42    enough to pass the test, please retake the topic that is giving you
42    problems.
42
42    Topic 1 described the "if", "if-else", "nesting", and "switch".
42
42    Topic 2 described the "while", "for", and "do-while" loops.
42
42    Topic 3 described the "break" and "continue" statements.
42
42    Topic 4 described the "label" and "goto" statements.
42
42    Good Luck on the test.
43END
51Frame 900 TT TEST OVER LESSON 3
52    Welcome to the final test of lesson three.  This test consists of ten
52    questions over material presented in the previous four topic areas.
52
52    In order to successfully complete this lesson, you must achieve a
52    minimum score of 70% (seven out of ten questions correct).
52
52    If you miss a question, the correct answer will not be shown.  It is
52    up to you to research the correct answer.
52
52    Well, enough said.  Let's get on with it.  Good luck!
53B:905
51Frame 905 QM
521.  Which one of the following is "not" one of the control statements that
52was covered in this lesson?
```

```
53A  if
53
53B  if-else
53
53C  switch
53
53D+ while
54 Right.      (1,100)
54 B:910
55ABC Wrong.      (1,100)
55 B:910
55E "E" was not one of your choices.
55 B:905
51Frame 910 QP
522.  Braces "{}" are used to form a "block" of one or more statements to be
52conditionally executed.  (True or False)
53Y
54 Right.      (1,120)
54 B:915
55 Wrong.      (1,120)
55 B:915
51Frame 915 QM
523.  Since the "else" part of the "if-else" control structure is optional,
52care must be taken to prevent which of the following from occuring?
53A  having the "else" statement skipped.
53
53B+ having the "else" applied to the wrong "if" statement.
53
53C  having an "else" applied to two "if" statements.
53
53D  having the "if" statement executed before the "else".
54 Right.      (1,150)
54 B:920
55BCD Wrong.      (1,150)
55 B:920
55E "E" was not one of your choices.
55 B:915
51Frame 920 QP
524.  Essentially, the "switch" is just a special case of the "if-else"
52structure, and its use is really just "programmer preference".
52(True or False)
53Y
54 Right.      (2,320)
54 B:925
55 Wrong.      (2,320)
55 B:925
51Frame 925 QM
525.  If the "loop control expression" in the "while" loop is "false" the first
52time it is checked, which of the following statements would be true?
53A  The loop body would be executed one time only.
53
53B  The loop would be executed until the control expression becomes "true".
```

```
53
53C+ The loop body would be skipped altogether.
53
53D  The loop would become an infinite loop.
54 Right.      (2,305)
54 B:930
55ABD Wrong.      (2,305)
55 B:930
55E "E" was not one of your choices.
55 B:925
51Frame 930 QM
526.  Which of the following is "not" a part of the "for" loop control
52structure?
53A  initialize expression
53
53B  test expression
53
53C  increment expression
53
53D+ terminate expression
54 Right.      (2,320)
54 B:935
55ABC Wrong.      (2,320)
55 B:935
55E "E" was not one of your choices.
55 B:930
51Frame 935 QP
527.  The major difference between the "while" loop and the "do-while" loop is
52that the "do-while" will always be executed at least once whereas the "while"
52loop may be skipped altogether if the loop control expression is "false".
52(True or False)
53Y
54 Right.      (2,345)
54 B:940
55 Wrong.      (2,345)
55 B:940
51Frame 940 QP
528.  The "break" statement can only be used to terminate a "while" or "for"
52loop before the "loop control expression" becomes false.  (True or False)
53N
54 Right.      (3,500)
54 B:945
55 Wrong.      (3,500)
55 B:945
51Frame 945 QM
529.  Which of the following structures is the "continue" statement not
52effectively used with?
53A  for loop
53
53B  do-while loop
53
53C+ switch
```

```
53
53D  while loop
54 Right.      (3,535)
54 B:950
55ABD Wrong.      (3,535)
55 B:950
55E "E" was not one of your choices.
55 B:945
51Frame 950 QM
5210.  When using the "goto" statement in your C program, which of the
52following must be adhered to?
53A+ The target "label statement" must be in the same function.
53
53B  The target "statement number" must be in the same function.
53
53C  The "goto" statement must not be in a loop structure.
53
53D  The "goto" statement must be before the "flagged" statement.
54 Right.      (4,710)
54 B:955
55BCD Wrong.      (4,710)
55 B:955
55E "E" was not one of your choices.
55 B:950
51Frame 955 T
52    *** End of Lesson Material ***
52
52    This marks the end of lesson number three.  I hope that it was of some
52    benefit to you.  I am looking forward to seeing you in lesson number
52    four.  I hope that you didn't have too much trouble with the material
52    presented in this lesson.  If you did, please voice your comments to
52    your training monitor who will in turn contact the CAI Plans Branch
52    at Keesler AFB, MS.
52
52    Well, let's take a look at how you did with the test ...
53END
```

File "LESSON4"

```
#      WW     WW  EEEEEEEE  LL          CCCCCCC   OOOOOO   MMM   MMM  EEEEEEEE
#      WW WW WW   EE        LL        CC         OO    OO  MMM   MMM  EE
#      WW WW WW   EEEEE     LL        CC         OO    OO  MM MM MM  EEEEE
#      WWW  WWW   EE        LL        CC         OO    OO  MM MM MM  EE
#      WWW  WWW   EEEEEEEE  LLLLLLLL   CCCCCCC   OOOOOO   MM     MM  EEEEEEEE
#
#
#                              TTTTTTTTTT    OOOOOOOO
#                                  TT       OO      OO
#                                  TT       OO      OO
#                                  TT       OO      OO
#                                  TT        OOOOOOOO
#
#
#      LL         EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN     NN        444
#      LL         EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NNN    NN       4444
#      LL         EE        SSS       SSS       OO    OO  NNNN   NN      44 44
#      LL         EEEEE      SSSS      SSSS     OO    OO  NN NN NN     44  44
#      LL         EEEEE        SSSS      SSSS   OO    OO  NN NN NN    44444444
#      LL         EE             SSS       SSS  OO    OO  NN  NNNN    44444444
#      LLLLLLLL   EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NN   NNN        44
#      LLLLLLLL   EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN     NN       44
!
#  THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INFORMATION ON ARRAYS, POINTERS,
#  AND ADDRESS ARITHMETIC USED IN  C  PROGRAMMING.
#
#  THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.
#
#
#  The Lesson Breakdown Is As Follows:
#
#  Topic 1:  Introducing Arrays - This topic introduces the declaration,
#            initialization, and use of arrays.  (Approx. time = 15 min.)
#
#
#  Topic 2:  Introducing Pointers - This topic introduces the declaration
#            and use of pointers.  (Approx. time = 15 min.)
#
#
#  Topic 3:  Working with Pointers I - This topic is the first of two that
#            covers how to work with pointers.  Emphasis is on how pointers
#            are passed to functions.  (Approx. time = 10 min.)
!
#  Lesson Breakdown Continued:
#
#  Topic 4:  Working with Pointers II - This topic is the second of two that
#            covers how to work with pointers.  Emphasis is on how pointers
#            are used in conjunction with arrays and the use of address
#            arithmetic.  (Approx. time = 10 min.)
#
```

```
#
#  Topic 5:  Lesson 4 Test - This is the lesson test over items that have
#            been presented in the previous four lesson topics.
#            (Approx. time = 5 min.)
#
#
#  TOTAL LESSON TIME IS APPROXIMATELY 55 MINUTES.
#
#
#  I hope that you enjoy it!
!
*****************************************************************************
*                                                                           *
*             SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:         *
*                                                                           *
*****************************************************************************
*                                                                           *
*     STATUS          TOPIC #           TOPIC TITLE                         *
*     ------          -------           -----------                         *
*                                                                           *
@                        1              Introducing Arrays                  *
*                                                                           *
@                        2              Introducing Pointers                *
*                                                                           *
@                        3              Working with Pointers I             *
*                                                                           *
@                        4              Working with Pointers II            *
*                                                                           *
@                        5              Test Over Lesson 4                  *
*                                                                           *
*****************************************************************************
*      NOTE:  A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.     *
*****************************************************************************
11Frame 100 T  Introducing Arrays
12    *** Introduction ***
12
12    An "array" is a group of contiguously stored related variables.
12
12    In this topic area we will take a look at the basic use of arrays and
12    some advanced concepts involving arrays.
12
12
12    To be more specific, we will be looking at:  one dimensional arrays,
12    multidimensional arrays, and array initialization.
12
12    Let's get started.
13B:105
11Frame 105 T
12    *** One Dimensional Arrays ***
12
12    The language C does not have a "string" variable type, therefore it
12    uses an array of characters to accomplish the same thing.  If you
```

```
12    think of a string of characters such as a sentence.  How would you
12    store it in your program?  Well, the answer of course is to use an
12    array of characters.
12
12    The structure of the basic one dimensional character array declaration
12    statement is:
12
12    char var_name[n];  where "n" is the number of characters in the array.
12
12    Now comes the tricky part.  The individual characters in the array
12    are called the "elements" of the array.  Accessing these elements is
12    a very common procedure in programming.  Let's look at an example that
12    uses an array and see how this is done.
13B:110
11Frame 110 T
12    * One Dimensional Arrays Continued *
12
12    For our example, let's say we want to store the word  Payment .  The
12    first thing we must do is decide on the size of the array that will
12    hold this word. This can be done by counting the number of characters
12    in the word.  So, let's see... I count 8.
12
12    At first glance it looks like I made a mistake in counting the charac-
12    ters in  Payment .  This is not the case.  In C the first element of
12    an array is stored in array position 0 (zero), and the last (string)
12    array position element is always a null character (\0).  So, using
12    the following statement to declare our word as a character string
12    constant...
12
12    char ex_word[8] = "Payment";
12
12    the array will be filled as follows:
13B:115
11Frame 115 T
12    * One Dimensional Arrays Continued *
12
12    ex_word[0] = P
12    ex_word[1] = a
12    ex_word[2] = y
12    ex_word[3] = m
12    ex_word[4] = e
12    ex_word[5] = n
12    ex_word[6] = t
12    ex_word[7] = \0
12
12    The "null character" stored at the end of a string array is put there
12    automatically by the C compiler.  All you have to worry about is to
12    leave room for it in your array.  What if you don't want to worry
12    about such things?  Well, there is a way to get around counting the
12    number of characters in a string constant and then adding one for the
12    null character.  Let's take a look.
13B:120
```

```
11Frame 120 T
12    * One Dimensional Arrays Continued *
12
12    Using the statement:  char ex_word[] = "Payment";  will accomplish the
12    same thing as the example we just looked at.  Namely, an array consis-
12    ting of eight elements will be declared and filled by the compiler.
12
12    The way in which the individual elements in an array are accessed is
12    by referencing the element using an index.  In our example an index of
12    4 would look like this:  ex_word[4] and yield the character  e .
12
12    Our discussion thus far has only dealt with the C character type.  The
12    use of arrays is by no means restricted to this C variable type.  Here
12    are a couple examples of arrays of other variable types:
12
12    int ex_ints[35];  This is an array of integers (36 of them).
12
12    float ex_floats[67];  An array of floating point reals (68 of them).
13B:125
11Frame 125 QM
12Given the character array declaration:  char example[n] = "Example";
12Which of the following is the correct number for "n" ?
13A  10
13
13B  9
13
13C+ 8
13
13D  7
14 Right.  Seven characters plus the "null character", therefore 8.
14 B:130
15ABD Wrong.  There are seven characters plus the "null character",
15    example[0] thru example[7], therefore the correct answer is 8 ("C").
15 B:130
11Frame 130 T
12    *** Multidimensional Arrays ***
12
12    As we have seen, a one dimensional array is declared using a statement
12    such as  char ex_word[8]; .  The dimension of this array is seen as a
12    list of characters running from ex_word[0] to ex_word[7].
12
12    A two dimensional array can be thought of as a table consisting of rows
12    and columns.  The way in which a two dimensional array is declared is
12    as follows:
12
12    int ex_int[n][m];  where "n" is the number of rows
12                       and "m" is the number of columns.
12
12    Let's look at an example.
13B:135
11Frame 135 T
12    * Multidimensional Arrays Continued *
```

```
12
12    If we want to store the test scores for a class of 5 students who have
12    each taken 4 tests, we could do it like this:
12
12    int scores[5][4] = {
12       {75,80,70,95},
12       {85,85,90,95},
12       {60,90,80,90},
12       {70,80,90,90},
12       {75,85,95,85}
12    };
12
12    This form is very representative of how the table would look.  How these
12    numbers are stored is as follows:  scores[0][0] = 75, scores[0][1] = 80,
12    scores[0][2] = 70, and scores[0][3] = 95.  You then increment the first
12    index and continue:  scores[1][0] = 85 ... scores[4][3] = 85.
13B:140
11Frame 140 T
12    * Multidimensional Arrays Continued *
12
12    In our example, we defined an array with 5 rows and 4 columns.  We
12    also filled the array with test scores.  Of course these test scores
12    are useless unless we have defined the student that each row represents.
12    This can be done several ways, but I would define a symbolic constant
12    for each student.  Such as:  #define Jones 0
12                                 #define Smith 1
12                                 #define Brown 2
12                                 #define Green 3
12                                 #define White 4
12
12    Now if you want to find out what Brown got on his third test you could
12    use the statement:  Brown_3 = scores[Brown,2];  This will retrieve the
12    score stored in array position scores[2][2], which was 80.
12
12    A good way I've found to get used to arrays is to experiment with them.
13B:145
11Frame 145 T
12    * Multidimensional Arrays Continued *
12
12    As you might have deduced by now, you can define arrays of more than
12    two dimensions.  All that needs to be done is add more brackets ([])
12    after the array name.
12
12    For example:  int four_D_array[5][10][5][20];
12
12    Don't ask me to give you a visual picture of such a thing, but I can
12    tell you that there are 5000 integer storage locations allocated by
12    such a declaration (5 x 10 x 5 x 20 = 5000).
13B:150
11Frame 150 QM
12Given the array declaration:  int array[2][5] = {
12                                 {75,80,70,95,65},
```

```
12                                  {85,60,90,50,55}  };
12
12Which of the following is the value stored in position  array[1][2] ?
13A  80
13B  60
13C+ 90
13D  85
13E  70
14 Very good.
14 B:155
15ABDE No.  Answer "C" is the correct one.
15 B:155
11Frame 155 T
12    *** Array Initialization ***
12
12    We have already seen some of the ways in which arrays are initialized.
12    When I gave an example of a one dimensional character array I used the
12    statement:
12
12       char ex_word[8] = "Payment";
12
12    That is one way to initialize the character array, another way would be:
12
12       char ex_word[] = "Payment";
12
12    Yet another way would be:
12
12       char ex_word[] = {'P','a','y','m','e','n','t','\0'};
12
12    All the above are correct if the array is a "global" array.
13B:160
11Frame 160 T
12    * Array Initialization Continued *
12
12    You may NOT initialize arrays that are "automatic".  This means any
12    arrays that are contained within a function.  In order to initialize
12    an array within a function it must be declared as "static".  The way
12    this is done is by use of the keyword "static".
12
12    For example:
12
12    This initialization is wrong.    |  This is the correct way.
12    ---------------------------------------------------------------------
12    sample() {                       |  sample() {
12       char array[] = "Example";     |     static char array[] = "Example";
12              .                     |              .
12              .                     |              .
12              .                     |              .
12    }                                |  }
13B:165
11Frame 165 T
12    * Array Initialization Continued *
```

```
12
12    When intilializing arrays other than character arrays, the initializing
12    is accomplished with values enclosed in braces.  For example:
12
12    A one dimensional global integer array can be initialized using:
12
12       int array[5] = {24,67,82,90,41};
12
12    Or, if all values of the array are being specified, the dimension can
12    be left out, as in:
12
12       int array[] = {24,67,82,90,41};
12
12    Again, if the array is local to a function and needs to be initialized,
12    use the keyword "static".
13B:170
11Frame 170 T
12    * Array Initialization Continued *
12
12    Multidimensional arrays are initialized by rows, as in one of our pre-
12    vious examples:
12
12       int scores[5][4] = {     |     int scores[][] = {
12          {75,80,70,95},        |        {75,80,70,95},
12          {85,85,90,95},        |        {85,85,90,95},
12          {60,90,80,90},        |        {60,90,80,90},
12          {70,80,90,90},        |        {70,80,90,90},
12          {75,85,95,85}         |        {75,85,95,85}
12       };                       |     };
12
12    If any of the values are missing, then the array value will be stored
12    as 0 (zero).  Note:  If values are missing, than dimensions must be
12    specified.  Of course "static" must be used for local function arrays
12    that you want to initialize.
13B:175
11Frame 175 QP
12The integer array initialization:  int array[] = {2,4,6,8};  is valid for
12a one dimensional integer array having 5 elements.  (True or False)
13N
14 Right.  If you intend for the array to have 5 elements then either 5 values
14 must be give in the list or a dimension of 5 must be explicitly stated.
14 B:180
15 Wrong.  If you intend for the array to have 5 elements then either 5 values
15 must be give in the list or a dimension of 5 must be explicitly stated.
15 B:180
11Frame 180 T
12    *** Topic Review ***
12
12    In this topic we have looked at "one dimensional" and "multidimensional"
12    arrays.  We have also seen how to initialize these arrays.
12
12    We have seen examples of what these arrays and initialization statements
```

```
12    look like, and how they are used.
12
12    In the next topic area I will describe pointers and give a few examples
12    of their use.
12
12    See you there!
12
12
12                    *** This concludes this topic area. ***
13END
21Frame 300 T  Introducing Pointers
22    *** Introduction ***
22
22    A "pointer" is a variable that contains the address of where some other
22    variable resides in memory.
22
22    In this topic area I will describe how pointers are declared and used
22    within a C program.
22
22    Since pointers can be very confusing to someone who has not seen them
22    before, I will restrict my discussion to elementary concepts and leave
22    their more advanced uses for your research.
22
22    Let's get started.
23B:305
21Frame 305 T
22    *** Pointers ***
22
22    In the declaration:  int var_one = 500;  a storage location is set
22    aside in memory for an integer variable and the value of 500 is
22    stored in that memory location.  That memory location also has a
22    memory address.
22
22    In C, you can determine the memory address by the use of the unary
22    operator  &  .
22
22    The way that you would assign a pointer variable to the memory location
22    where "var_one" is located is:  point_v1 = &var_one;  this assigns the
22    address of the variable "var_one" to the variable "point_v1".
22
22    Note:  Pointer names follow the same rules as other variable types and
22           must be declared as the same type of the variable being pointed
22           to (as we'll see later).
23B:310
21Frame 310 T
22    * Pointers Continued *
22
22    That's fine.  Now we know how to find out the memory address of a
22    variable, but what good is it?
22
22    It would be nice if we could now find out the value stored at the
22    address pointed to by our pointer.  C just happens to have a special
```

```
22    operator that allows us to do just that.
22
22    In C, you can determine the value stored at an address pointed to by
22    pointer by the use of the unary operator  *  .
22
22    The way that you would use this operator to find the value stored at
22    a pointed to address is:  var1_val = *point_v1;  this statement assigns
22    the value stored at the memory location pointed to by "point_v1" to
22    the variable "var1_val".  Which, in our example, would be 500.
23B:315
21Frame 315 T
22    * Pointers Continued *
22
22    To help clear up what we have done so far, let's look at our example
22    again and compare it to statements we are familiar with.
22
22    The sequence of statements:  var_one = 500;
22                                 point_v1 = &var_one;
22                                 var1_val = *point_v1;
22
22    Is the same as the sequence of statements:  var_one = 500;
22                                                var1_val = var_one;
22
22    In both of the above cases, the variable "var1_val" is assigned the
22    value of 500.  Although the use of the first set of statements seems
22    to be an unnecessary complication of a straightforward assignment,
22    keep in mind that this is just an example to demonstrate how a pointer
22    is used but does not show the true power of pointer usage.
23B:320
21Frame 320 QM
22The two unary operators used when working with pointers are the _____ and
22the _____.
23A  # and &
23
23B+ & and *
23
23C  $ and &
23
23D  $ and #
23
23E  # and *
24 Right.
24 B:325
25ACDE Wrong.  Answer "B" is the correct response.
25 B:325
21Frame 325 T
22    *** Pointer Declaration ***
22
22    In order for pointers to be used in a C program, you must declare a
22    pointer variable before you can use it.  The type of the pointer
22    variable must be the same as the variable that it is to point to.
22
```

```
22    In our example, the statement:  point_v1 = &var_one;  must be preceded
22    by the declaration:  int *point_v1;  which states that the value to be
22    pointed to by "point_v1" is of type "int".
22
22    Pointers to other types of variables are declared in the same way.
22    For example:
22
22    char *char_point;  declares the pointer variable "char_point" which
22                       is to point to a variable of type "char".
23B:330
21Frame 330 QP
22The declaration:  float *var_point;  declares the pointer variable
22                 "var_point" to be of type "float".
23N
24 Very good.  It declares the pointer variable "var_point" which "points"
24 to a variable of type "float".
24 B:335
25 No.  It declares the pointer variable "var_point" which will "point"
25 to a variable of type "float".
25 B:335
21Frame 335 T
22    *** Pointer Facts ***
22
22    Pointers can be used in expressions.  For example:
22
22    answer = *point + 35;  adds 35 to the value pointed to by "point" and
22                           stores the result in variable "answer".
22
22    *p_1 = *p_2 * 5;  multiplies the value pointed to by "p_2" by 5 and
22                      stores the result in the variable pointed to by "p_1".
22
22    p_one = p_two;  will make "p_one" point to the same variable that
22                    "p_two" points to if both "p_one" and "p_two" are
22                    declared to point to the same variable type.
22                    (i.e. int *p_one, *p_two;)
23B:340
21Frame 340 T
22    *** Topic Review ***
22
22    In this topic we have looked at pointer declaration and a few elemen-
22    tary examples of how they are used.
22
22    The rest of this lesson will discuss some other uses of pointers in
22    C programming.
22
22    In the next topic area (3) I will describe and show examples of how
22    to pass pointers as function arguments.  In topic area four I will
22    discuss the use of pointers in conjunction with arrays and explain
22    how to do address arithmetic.
22
22    Hope I see you there!
22
```

```
22
22                  *** This concludes this topic area. ***
23END
31Frame 500 T  Working with Pointers I
32    *** Introduction ***
32
32    In the last topic area we saw that a "pointer" is actually a vari-
32    able that contains the address of where some other variable resides
32    in memory.
32
32    In this topic area I will describe how pointers are passed to func-
32    tions, a rationale for doing it, and a few examples.
32
32
32    Let's get started!
33B:505
31Frame 505 T
32    *** Function Augument Background ***
32
32    We have seen two methods of passing arguments to a function, although
32    I have not explicitly named these methods.  Now is as good a time as
32    any to do so.  They are:  "Call by value" and "Call by reference".
32    The main difference in the two is that the actual value stored in a
32    variable can only be changed by using the "Call by reference" method
32    of argument passing.  Let's look at a couple of examples to help make
32    this clear.
32
32    Let's say we have a C program that has two functions "main" and "add".
32    The "main" function calls the "add" function and passes it two vari-
32    ables "x" and "y".  The "add" function takes the two arguments and
32    adds 50 to the first (x) and 75 to the second (y).  The "main" func-
32    tion then prints out the two variables "x" and "y".
32
32    Let's see what these two functions might look like.
33B:510
31Frame 510 T
32    add(x,y)                        ¦  This is a clear example of the "Call by
32      int x,y;                      ¦  value" method.  Even though I called the
32      {                             ¦  two variables the same name in both of
32       x += 50;                     ¦  the functions, each function has its own
32       y += 75;                     ¦  copy of the variables. Hence, the actual
32       retu n;                      ¦  values of "x" and "y" in "main" are never
32    }                               ¦  changed by the function "add". This will
32                                    ¦  result in "10" and "30" being printed by
32    main() {                        ¦  the "main" function.  One way around this
32      int x,y;                      ¦  problem is to make "x" and "y" global to
32      x = 10;                       ¦  both functions. The perfered method is to
32      y = 30;                       ¦  use "pointers" as we will see shortly.
32      add(x,y);                     ¦  To introduce us to the concept used in
32      printf("\n%d  %d",x,y);       ¦  passing pointers, let's look at another
32    }                               ¦  example.
33B:515
```

```
31Frame 515 T
32    For this example let's say we have two functions "main" and "init".
32    The "main" function declares an array called "line" to be a sequence
32    of 80 characters.  The "main" function calls the "init" function and
32    passes it the array to be initialized to blanks.
32
32    init(b_line)                 ¦  This is a clear example of the "Call by ref-
32      char b_line[];             ¦  erence" method. Although I called the array
32      {                          ¦  different names in the two functions, the
32       for (i=0;i<80;i++)        ¦  "init" function will actually change the
32         b_line[i] = ' ';        ¦  array "line" declared in function "main".
32    }                            ¦  This is because the function "main" actually
32                                 ¦  passes the address of where the array "line"
32    main() {                     ¦  begins in memory to the function "init".
32      char line[80];             ¦  This "Call by reference" only works in the
32      init(line);                ¦  case of arrays.  Before we look at pointer
32    }                            ¦  passing, let me ask you a quick question.
33B:520
31Frame 520 QP
32The "Call by value" method of argument passing only passes a copy of a
32variable, whereas the "Call by reference" method passes the address of
32the argument.  (True or False)
33Y
34 Right.  You have been paying close attention.
34 B:525
35 Wrong.  I hope you aren't falling asleep on me.
35 B:525
31Frame 525 T
32    *** Passing Pointers ***
32
32    We've seen in another lesson that a called function can only return
32    one value to the calling function.  Thus, only one value of the call-
32    ing function is truely changed.  This of course precludes the use of
32    global variables by the functions in question.
32
32    If it is necessary for the called function to change more than one
32    variable of the calling function, then the perfered method is to use
32    addresses or pointers as passed arguments.
32
32    There are three ways in which to accomplish the task introduced above.
32
32    1. Pass the address of the variable.
32    2. Pass a pointer to the variable.
32    3. Pass an array name.
33B:530
31Frame 530 T
32    * Passing Pointers Continued *
32
32    If we have a function that is to be called and its "function" is to
32    change two variables (as in our first example), we can set up the
32    function to receive pointers as its arguments as follows:
32
```

```
32    add(px,py)              ¦  In this example I have identified the variables
32      int *px,*py;          ¦  "px" and "py" to be pointers to variables of
32      {                     ¦  type "int".  When the function is executed, the
32       *px += 50;           ¦  values stored in the variables, pointed to by
32       *py += 75;           ¦  these pointers, will change by "50" and "75"
32       return;              ¦  respectively.
32    }
32
32    Let's look at how we would pass the "addresses" of the variables to this
32    function from our "main" function.
33B:535
31Frame 535 T
32    * Passing Pointers Continued *
32
32    One way we have identified as being a way to pass a pointer to a
32    function is by passing the "address".  The following illustrates
32    this method.
32
32    main() {                  ¦  In this example the only statement that
32      int x,y;                ¦  has changed from when you last saw it is
32      x = 10;                 ¦  the "add" function call statement.  All
32      y = 30;                 ¦  I did was to use the unary operator  &
32      add(&x,&y);             ¦  to identify the arguments as the address
32      printf("\n%d  %d",x,y); ¦  of the variables.
32    }                         ¦
32
32    Now let's look at another way to pass pointers from the calling
32    function to the called function.
33B:540
31Frame 540 T
32    * Passing Pointers Continued *
32
32    An alternate way of passing pointer information is to pass the pointer
32    itself.  The following illustrates this method.
32
32    main() {                  ¦  In this example the variables "px" and
32      int x,y,*px,*py;        ¦  "py" are identified as pointers to vari-
32      x = 10;                 ¦  ables of type "int".  The addresses of
32      y = 30;                 ¦  the variables "x" and "y" are stored in
32      px = &x;                ¦  those pointer variables and they are used
32      py = &y;                ¦  as arguments in the "add" function call
32      add(px,py);             ¦  statement.  Again, after execution of the
32      printf("\n%d  %d",x,y); ¦  "add" function, the new values of "x" and
32    }                         ¦  "y" will be printed out.
32
32    The third method of passing pointer information (pass an array name)
32    was already discussed.
33B:545
31Frame 545 QM
32Which of the following is "not" one of the ways in which to pass information
32that will allow the value of a variable to be changed by a called function?
33A  Pass a pointer to the variable.
```

```
33
33B  Pass an array name.
33
33C+ Pass the variable name.
33
33D  Pass the address of the variable.
34 Very good.
34 B:550
35ABD No.  That is one of the ways "to" do it.  The correct response is "C".
35 B:550
35E "E" was not a given choice.  Please try again.
35 B:545
31Frame 550 T
32    *** Topic Review ***
32
32    In this topic area we have looked at the "Call by reference" and "Call
32    by value" methods of argument passing as well as how to pass pointers
32    as function arguments.
32
32    We have seen several examples to help illustrate all of these methods.
32
32    In the next topic area I will describe the use of pointers in conjunc-
32    tion with arrays and explain how to use address arithmetic.
32
32    Hope to see you there!
32
32
32                  *** This concludes this topic area. ***
33END
41Frame 700 T  Working with Pointers II
42    *** Introduction ***
42
42    In this topic area I will describe how pointers are used in conjunction
42    with arrays and how to use address arithmetic.
42
42    We have seen already that when you declare an array with a statement
42    like:  char line[] = "This is an example";  the compiler sets up 19
42    contiguous storage locations in memory.  These locations have names
42    line[0] thru line[18].
42
42    We also have seen how to refer to each individual storage location
42    using an "index" value.  If "i" is a integer then line[i] refers to
42    the "i"th element in array "line".  You can manipulate "i" in order
42    to give you quick and easy access to any of the elements of the array.
42
42    Let's now see how we can use pointers to give us access and manipula-
42    tive power over arrays.
43B:705
41Frame 705 T
42    *** Array Access Thru Pointers ***
42
42    When an array is declared (char line[10];) the array can be passed
```

```
42    between fuctions by just giving the array name.  For example:
42
42    init(line);  This calls the function "init" and passes the array "line".
42
42    What actually happens is the C compiler passes the address of the "0"th
42    element of the array.  So in essence, a pointer to the beginning of the
42    array is passed ("line" being the pointer).
43B:710
41Frame 710 T
42    * Array Access Thru Pointers Continued *
42
42    The same thing can be accomplished by explicitly defining a pointer
42    in the following manner:
42
42    char *p_line;  This identifies "p_line" as a pointer to a variable of
42                   type "char".
42
42    p_line = &line[0];  This assigns the address of the "0"th element of
42                        array "line" to the pointer variable "p_line".
42
42    init(p_line);  This calls the function "init" and passes the address
42                   of the starting location of array "line".
42
42    Once the above declarations have been made, the two expressions:
42    "line" and "p_line" are interchangeable.
43B:715
41Frame 715 QM
42If you have the declaration:  char line[10];  which of the following state-
42ments will assign the address of the "0"th element to a pointer variable
42that has been declared using the statement:  char *p_line; ?
43A  *p_line = line[0];
43
43B  p_line = line[0];
43
43C  *p_line = &line[0];
43
43D+ p_line = &line[0];
44 Right.
44 B:720
45ABC Wrong.  Answer "D" is the correct response.
45 B:720
45E "E" was not a given choice.  Please try again.
45 B:715
41Frame 720 T
42    * Array Access Thru Pointers Continued *
42
42    The next logical step in our discussion is to look at how we can access
42    the individual elements of an array using our declared pointer.
42
42    We already know that "line[0]" will give us access to the "0"th element
42    of the array "line", but now that "p_line" has the address of the "0"th
42    element of the array, we can also use the expression "*p_line" to accom-
```

```
42    plish the same effect.  Note:  It is also legal to use the notation
42    "p_line[0]", but we will avoid this to cut down on the confusion.
42
42    Now that we have pointer access to the array, we can manipulate the
42    pointer to point to any of the array elements by use of address arith-
42    metic.
43B:725
41Frame 725 T
42    *** Address Arithmetic ***
42
42    The most common use of address arithmetic is through the use of the
42    increment, decrement, addition, and subtraction operators.
42
42    The operation must involve a pointer and an integer with the exception
42    of the subtraction operator (subtraction/comparison of two pointers is
42    allowed).
42
42    The use of "relational" operators is legal as long as the pointers
42    point to members of the same array.  The use of the "operational
42    assignment" operators "+=" and "-=" are also legal.
42
42    Let's look at an example of how to use some of these operators.
43B:730
41Frame 730 T
42    * Address Arithmetic Continued *
42
42    When we first started this topic area I used the declaration state-
42    ment:  char line[] = "This is an example";  to declare and initialize
42    the array "line".
42
42    Using the declarations:  char *p_line;  and  p_line = &line[0];  we
42    established a pointer to the "0"th element of array "line".
42
42    We also saw that the expressions "line[0]" and "*p_line" are equivalent.
42
42    Both would return a value of  T  if used in a statement such as:
42
42            char_val = line[0];     OR     char_val = *p_line;
43B:735
41Frame 735 T
42    * Address Arithmetic Continued *
42
42    We can move forward and backward in the array by using our pointer
42    and the legal operators mentioned before.
42
42    If we want to move one element forward in the array we can use the in-
42    crement operator (++), the addition operator (+), or the operational
42    assignment operator (+=).
42
42    For example:  p_line++  will make the pointer point to the next se-
42    quential element in the array.  Likewise, p_line = p_line + 1; and
42    p_line += 1;  will have the same effect.
```

```
42
42    In general, it can now be said that if "p_line" is a pointer and "i"
42    is an integer, then  p_line += i  will increment "p_line" by "i" thus
42    making "p_line" point to an element "i" elements beyond its present
42    location.  Decrementing is done in a similar fashion.
43B:740
41Frame 740 QM
42Given that "pa_val", "pb_val", and pc_val are pointers.  Which of the fol-
42lowing statements is "not" a "legal" address arithmetic operation?
43A+ pc_val = pb_val + pa_val;
43
43B  pc_val = pb_val - pa_val;
43
43C  pa_val += (pb_val += pc_val);
43
43D  pa_val -= (pb_val - pc_val);
44 Very good.  Addition of two pointers is not allowed.
44 B:745
45BCD Wrong.  That is a valid statement involving address arithmetic.
45 B:745
45E "E" was not a given choice.  Please try again.
45 B:740
41Frame 745 T
42    *** Lesson Four Summary ***
42
42    Well, we have come to the end of lesson four.  If you have seen the
42    four subject topics in this lesson, you should now be ready to take
42    the final test.  If you feel that you don't understand something well
42    enough to pass the test, please retake the topic that is giving you
42    problems.
42
42    Topic 1 gave an introduction to one and multidimensional arrays.
42
42    Topic 2 gave an introduction to pointers and their use.
42
42    Topic 3 gave a description of how pointers are passed to functions.
42
42    Topic 4 gave a description of pointer use in conjunction with arrays.
42
42    Good Luck on the test.
43END
51Frame 900 TT TEST OVER LESSON 4
52    Welcome to the final test of lesson four.  This test consists of ten
52    questions over material presented in the previous four topic areas.
52
52    In order to successfully complete this lesson, you must achieve a
52    minimum score of 70% (seven out of ten questions correct).
52
52    If you miss a question, the correct answer will not be shown.  It is
52    up to you to research the correct answer.
52
52    Well, enough said.  Let's get on with it.  Good luck!
```

```
53B:905
51Frame 905 QM
521.  In the array declaration:  char word[x] = "Sample";  which of the
52following is the correct value for "x" ?
53A  9
53
53B  8
53
53C+ 7
53
53D  6
54 Right.      (1,110)
54 B:910
55ABD Wrong.      (1,110)
55 B:910
55E "E" was not one of your choices.
55 B:905
51Frame 910 QM
522.  Given the array declaration:  int array[2][4][6];  how many integer
52storage locations are allocated?
53A  12
53
53B  24
53
53C  36
53
53D+ 48
54 Right.      (1,145)
54 B:915
55ABC Wrong.      (1,145)
55 B:915
55E "E" was not one of your choices.
55 B:910
51Frame 915 QF
523.  The integer array initialization:  int array[5] = {4,8,12};  is valid
52for a one dimensional integer array having 5 elements.  (True or False)
53Y
54 Right.      (1,170)
54 B:920
55 Wrong.      (1,170)
55 B:920
51Frame 920 QM
524.  Which of the following is the unary operator that is used to determine
52the memory address of a variable?
53A  @
53
53B  #
53
53C  %
53
53D+ &
53
```

```
53E  *
54 Right.      (2,305)
54 B:925
55ABCE Wrong.      (2,305)
55 B:925
51Frame 925 QP
525.  The declaraction:  char *char_point;  declares the pointer variable
52"char_point" which points to a variable of type "char".  (True or False)
53Y
54 Right.      (2,325)
54 B:930
55 Wrong.      (2,325)
55 B:930
51Frame 930 QP
526.  The "Call by reference" method of argument passing only passes a copy
52of a variable, whereas the "Call by value" method passes the address of
52the argument.  (True or False)
53N
54 Right.      (3,510-515)
54 B:935
55 Wrong.      (3,510-515)
55 B:935
51Frame 935 QM
527.  Given:  main () {
52              int x,y,*px,*py;
52              x = y = 0;
52              px = &x;
52              py = &y;
52              change(px,py);  }
52
52Which of the following is the method of pointer passing used?
53A+ Pass a pointer to the variable.
53B  Pass an array name.
53C  Pass the address of the variable.
53D  Pass the variable name.
54 Right.      (3,540)
54 B:940
55BCD Wrong.      (3,540)
55 B:940
55E "E" was not one of your choices.
55 B:935
51Frame 940 QM
528.  Given the declaration:  int array[10];  which of the following state-
52ments will assign the address of the third element to a pointer variable
52that has been declared using the statement:  int *p_array; ?
53A  *p_array = &array[2];
53
53B+ p_array = &array[2];
53
53C  *p_array = array[2];
53
53D  p_array = array[2];
```

```
54 Right.      (4,710)
54 B:945
55ACD Wrong.      (4,710)
55 B:945
55E "E" was not one of your choices.
55 B:940
51Frame 945 QP
529.  The statement:  init(p_var);  calls the function "init" and passes the
52address of the variable pointed to by the pointer "p_var", provided the
52pointer was declared using a statement like "int *p_var;".  (True of False)
53Y
54 Right.      (4,710)
54 B:950
55 Wrong.      (4,710)
55 B:950
51Frame 950 QM
5210.  Which of the following operators is "not" a legal operator in address
52arithmetic?
53A  +
53
53B  -
53
53C  +=
53
53D  --
53
53E+ /
54 Right.      (4,725)
54 B:955
55ABCD Wrong.      (4,725)
55 B:955
51Frame 955 T
52    *** End of Lesson Material ***
52
52    This marks the end of lesson number four.  I hope that it was of some
52    benefit to you.  I am looking forward to seeing you in lesson number
52    five.  I hope that you didn't have too much trouble with the material
52    presented in this lesson.  If you did, please voice your comments to
52    your training monitor who will in turn contact the CAI Plans Branch
52    at Keesler AFB, MS.
52
52    Well, let's take a look at how you did with the test ...
53END
```

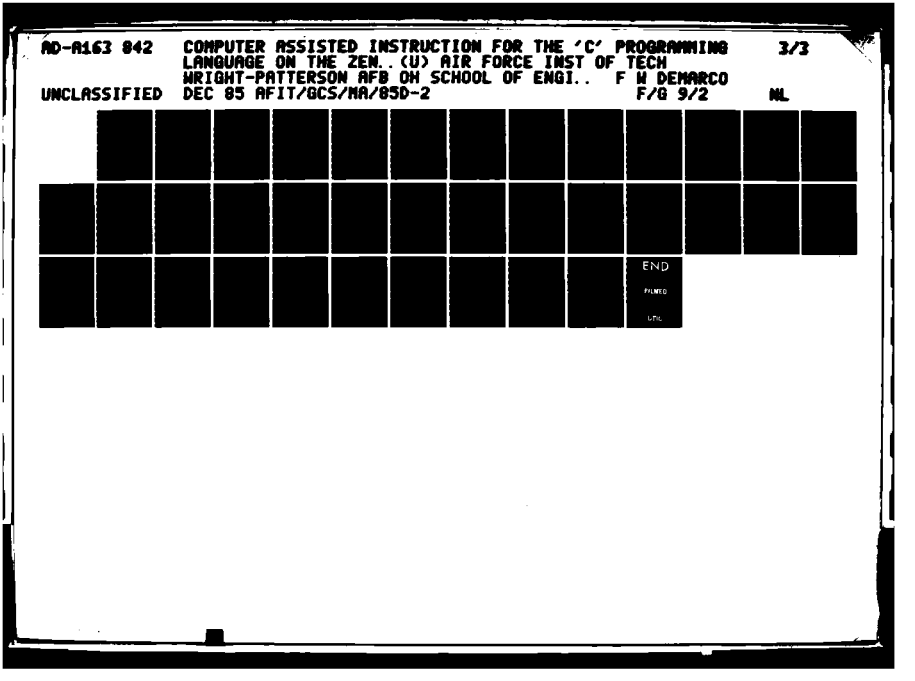
File "LESSON5"

```
#      WW     WW  EEEEEEEE  LL          CCCCCCC   OOOOOO   MMM  MMM  EEEEEEEE
#      WW WW WW   EE        LL        CC         OO    OO  MMM  MMM  EE
#      WW WW WW   EEEEE     LL        CC         OO    OO  MM MM MM  EEEEE
#      WWW  WWW   EE        LL        CC         OO    OO  MM MM MM  EE
#      WWW  WWW   EEEEEEEE  LLLLLLLL   CCCCCCC   OOOOOO   MM    MM  EEEEEEEE
#
#
#                              TTTTTTTTTT    OOOOOOOO
#                                  TT       OO      OO
#                                  TT       OO      OO
#                                  TT       OO      OO
#                                  TT        OOOOOOOO
#
#
#      LL          EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN    55555555
#      LL          EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NNN   NN    55555555
#      LL          EE        SSS       SSS       OO    OO  NNNN  NN    55
#      LL          EEEEE      SSSS      SSSS     OO    OO  NN NN NN    555555
#      LL          EEEEE        SSSS      SSSS   OO    OO  NN NN NN    5555555
#      LL          EE             SSS       SSS  OO    OO  NN  NNNN         555
#      LLLLLLLL    EEEEEEEE  SSS  SSS  SSS  SSS  OOOOOOOO  NN   NNN    55555555
#      LLLLLLLL    EEEEEEEE   SSSSSS    SSSSSS    OOOOOO   NN    NN     555555
!
#  THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INFORMATION ON STRUCTURES THAT
#  ARE USED IN  C  PROGRAMMING.
#
#  THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.
#
#
#  The Lesson Breakdown Is As Follows:
#
#  Topic 1:  Introducing Structures - This topic introduces the idea of
#            structures and two methods of declaring them.
#            (Approx. time = 10 min.)
#
#
#  Topic 2:  Structures and Arrays - This topic describes the use of struc-
#            tures within structures and arrays of structures.
#            (Approx. time = 5 min.)
#
#
#  Topic 3:  Structures and Pointers - This topic describes how to use point-
#            ers in conjunction with structures.  (Approx. time = 5 min.)
!
#  Lesson Breakdown Continued:
#
#  Topic 4:  Structures and Functions - This topic describes how structures
#            are passed between functions.  (Approx. time = 5 min.)
#
#
```

```
#  Topic 5:  Lesson 5 Test - This is the lesson test over items that have
#            been presented in the previous four lesson topics.
#            (Approx. time = 5 min.)
#
#
#  TOTAL LESSON TIME IS APPROXIMATELY 30 MINUTES.
#
#
#  I hope that you enjoy it!
;
*****************************************************************************
*                                                                           *
*             SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:         *
*                                                                           *
*****************************************************************************
*                                                                           *
*     STATUS          TOPIC #          TOPIC TITLE                          *
*     ------          -------          -----------                          *
*                                                                           *
@                        1             Introducing Structures               *
*                                                                           *
@                        2             Structures and Arrays                *
*                                                                           *
@                        3             Structures and Pointers              *
*                                                                           *
@                        4             Structures and Functions             *
*                                                                           *
@                        5             Test Over Lesson 5                   *
*                                                                           *
*****************************************************************************
*      NOTE:  A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.     *
*****************************************************************************
11Frame 100 T  Introducing Structures
12    *** Introduction ***
12
12    A "structure" is typically a group of related variables, of possibly
12    different types, under a single structure name.
12
12    In this topic area we will take a look at the concept of a "structure"
12    and two methods of declaring them.
12
12    We will also be discussing how to access the individual members of a
12    declared structure.  We will see several examples of elementary
12    structures in order to get you introduced to their declaration and
12    use.
12
12    Let's get started.
13B:105
11Frame 105 T
12    *** Structures ***
12
```

```
12    Whenever you have a group of related items it is nice to be able to
12    group them in such a way as to give quick and easy access.  In C,
12    the way this is done is through the use of "structures".
12
12    For example, if you have information about a student at a university,
12    this information might include items such as:  Name, Address, Major,
12    GPA, and Advisor.  Instead of keeping all this information stored
12    separately we can form a structure with five parts containing the
12    needed information.
12
12    Let's take a look at one way to declare our structure.
13B:110
11Frame 110 T
12    *** Declaring Structures ***
12
12    Our first way of declaring a structure uses the keyword "struct"
12    followed by an open brace "{" followed by the declaration of the
12    item variables followed by the close brace "}" followed by the
12    structure name followed by a semicolon.
12
12    For our example this would look something like this:
12
12    struct {                          ¦  Each of the character arrays must
12       char name[NAME_SIZE];          ¦  have predeclared constant values
12       char address[ADDRESS_SIZE];    ¦  for their sizes, hence the use of
12       char major[MAJOR_SIZE];        ¦  capital letter names. You could
12       float gpa;                     ¦  have broken "name" or "address"
12       char advisor[ADVISOR_SIZE];    ¦  into several variables or even
12    } student;                        ¦  other structures as we'll see later.
13B:115
11Frame 115 T
12    * Declaring Structures Continued *
12
12    The "structure name" need not be a single variable name.  You can give
12    several different names to the same structure type by listing the names
12    seperated by commas.
12
12    For example:
12
12    struct {
12       int wing_span;
12       int num_tires;
12       double tonage;
12       double fuel_cap;
12    } F_16, C_141, C_5A, KC_135;
12
12    This example shows how you can define a standard information structure
12    that can be used for several different types of aircraft.
13B:120
11Frame 120 QP
12The use of structures allows for the grouping of related variables into
12a form which will be easy and quick to access.  (True or False)
```

```
13Y
14 That's right.
14 B:125
15 Wrong.  It is easy and quick, as you will shortly see.
15 B:125
11Frame 125 T
12    * Declaring Structures Continued *
12
12    Our second way of declaring a structure uses a sort of "template" for
12    the composition of the structure variables.
12
12    This way of declaring a structure uses the keyword "struct" followed by
12    a structure tag followed by an open brace "{" followed by the declara-
12    tion of the item variables followed by the close brace "}" followed by
12    a semicolon.  For our "student" example this would look something like:
12
12    struct stu_rec {                  ¦  As you can see, the structure name
12       char name[NAME_SIZE];          ¦  has been droped and I have added the
12       char address[ADDRESS_SIZE];    ¦  structure tag name of "stu_rec".
12       char major[MAJOR_SIZE];        ¦  Defining structures in this way will
12       float gpa;                     ¦  allow you to define a variable of
12       char advisor[ADVISOR_SIZE];    ¦  this type within your program when-
12    };                                ¦  ever you need it.
13B:130
11Frame 130 T
12    * Declaring Structures Continued *
12
12    The major difference between the two methods of declaring structures
12    is that the first method will allocate memory space for the structure
12    variable when the program is run through the C compiler, and the second
12    method doesn't.
12
12    The second method only defines a structure type which you can use in
12    later variable declarations.  For example, if you have several students
12    that you wish to identify within your program, you can use the follow-
12    ing declaration to allocate memory space for them:
12
12    struct stu_rec student_1, student_2, student_3;
12
12    This declares the variables "student_1", "student_2", and "student_3"
12    to be structures of type "stu_rec".
13B:135
11Frame 135 T
12    *** Structure Variable Access ***
12
12    Now that we have seen how to declare structures, it is now time to see
12    how to access the individual members of the structure.
12
12    Access to these individual structure members is gained through the use
12    of the structure member operator  . (period).
12
```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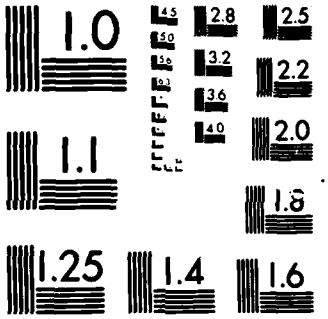

```
12    For example:  student.gpa  would be how you reference the "gpa" float
12    variable within the "student" structure that I declared using the
12    first method of structure declaration.  Whereas,  student_1.gpa  is
12    how to reference the "gpa" float variable within the "student_1" struc-
12    ture (of type "stu_rec") that was declared using the second method.
12
12    Let's look at another example to be sure you understand this concept.
13B:140
11Frame 140 T
12    * Structure Variable Access Continued *
12
12    struct employees {       ¦  This declaration sets up a "template" for a
12       int num_male;         ¦  structure of type "employees" as well as
12       int num_female;       ¦  declares "dep_1" to be a variable of that
12       int num_over_40;      ¦  type.  This is a legal declaration that com-
12       int num_under_40;     ¦  bines both methods of structure declaration.
12    } dep_1;                 ¦  I show it here to make you aware of its use.
12
12    The way in which you would reference the individual members of the
12    declared structure "dep_1" is as follows:
12
12    dep_1.num_male           ¦  Each of these individual variable members of
12    dep_1.num_female         ¦  the structure can be used as you would any
12    dep_1.num_over_40        ¦  variable of their individual type ("int").
12    dep_1.num_under_40       ¦  Let's now take a quick look at how you can
12                             ¦  initialize a structure.
13B:145
11Frame 145 T
12    *** Structure Initialization ***
12
12    A structure may be initalized by listing the member values after the
12    structure name declaration.  The following two examples show how this
12    is done.
12
12    struct {                 ¦  struct planes {
12       int tot_num;          ¦     int tot_num;
12       int tot_maint;        ¦     int tot_maint;
12       int tot_avail;        ¦     int tot_avail;
12    } planes = {50,5,45};    ¦  };
12                             ¦  struct planes F_16 = {50,5,45};
13B:150
11Frame 150 QM
12Given the structure declaration:  struct houses {
12                                     int num_white;
12                                     int num_green;
12                                     int num_brick;
12                                  } quarters = {165,139,127};
12
12Which of the following is a way to increase the "num_brick" variable to 137 ?
13A  houses.num_brick += 10;
13B  quarters.houses.num_brick += 10;
13C+ quarters.num_brick += 10;
```

```
13D  houses.quarters.num_brick += 10;
14 Very good.
14 B:155
15ABD No.  Answer "C" is the correct one.
15 B:155
15E "E" was not a given choice.  Please try again.
15 B:150
11Frame 155 T
12    *** Topic Review ***
12
12    In this topic we have looked at the concept of a structure and we
12    examined two methods of declaring them.
12
12    We have seen how to access the individual members of a declared struc-
12    ture, and we also saw how you can initialize a structure when it is
12    declared.  We have seen examples of what these structures look like
12    and how they can be used.
12
12    In the next topic area I will describe "structures within structures"
12    and "arrays of structures".
12
12    See you there!
12
12
12                    *** This concludes this topic area. ***
13END
21Frame 300 T  Structures and Arrays
22    *** Introduction ***
22
22    In this topic area I will describe how structures are used within
22    structures and how to declare and use an array of structures.
22
22    The uses for these two capabilities is unlimited to say the least.
22
22    The description of how to use these two capabilities is very straight-
22    forward, so this won't take long.
22
22    Note:  Variable names in all CAPS are assumed to be declared constants.
22
22    Let's get to it.
23B:305
21Frame 305 T
22    *** Structures Within Structures ***
22
22  As you may have deduced by now, there is no restriction on the types of
22  variables used within a structure.  Therefore, we can have a structure
22  that contains a variable that is itself a structure.
22
22  For example:
22
22  Declare "employee"     * Declare "home"          * Declare "wage_earner"
```

```
22  ********************************************************************************
22  struct employee {      * struct home {          * struct {
22     char f_name[FSIZE]; *    char street[SSIZE]; *    struct employee name;
22     char m_init;        *    char city[CSIZE];   *    struct home address;
22     char l_name[LSIZE]; *    long zip;           *    float wage;
22  };                     * };                     * } wage_earner;
23B:310
21Frame 310 T
22    * Structures Within Structures Continued *
22
22    We can now use the structure member operator (.) to gain access to a
22    specific member of our declared structure "wage_earner".
22
22  Given:
22
22  Structure "employee"   * Structure "home"       * Structure "wage_earner"
22  ********************************************************************************
22  struct employee {      * struct home {          * struct {
22     char f_name[FSIZE]; *    char street[SSIZE]; *    struct employee name;
22     char m_init;        *    char city[CSIZE];   *    struct home address;
22     char l_name[LSIZE]; *    long zip;           *    float wage;
22  };                     * };                     * } wage_earner;
22
22  wage_earner.name.m_init  will access the character variable used for a
22  wage earners middle initial.
23B:315
21Frame 315 QM
22  Structure "employee"   * Structure "home"       * Structure "wage_earner"
22  ********************************************************************************
22  struct employee {      * struct home {          * struct {
22     char f_name[FSIZE]; *    char street[SSIZE]; *    struct employee name;
22     char m_init;        *    char city[CSIZE];   *    struct home address;
22     char l_name[LSIZE]; *    long zip;           *    float wage;
22  };                     * };                     * } wage_earner;
22
22Given the above, which of the following is "not" a valid variable access
22expression?
23A  wage_earner.wage
23B  wage_earner.address.zip
23C+ wage_earner.home.street
23D  wage_earner.name.m_init
24 Right.
24 B:320
25ABD Wrong.  Answer "C" is the correct response.
25 B:320
25E "E" was not a given choice, please try again.
25 B:315
21Frame 320 T
22    *** Arrays of Structures ***
22
22    Now that we have seen how to have structures within structures, let's
22    take a look at how to declare an array of structures.
```

```
22
22    First we need to declare a structure:
22
22    struct address {
22       char street[S_SIZE];
22       char city[C_SIZE];
22       long zip;
22    };
22
22    We can now declare an array of this type of structure:
22
22    struct address student[100];
23B:325
21Frame 325 T
22    * Arrays of Structures Continued *
22
22    The statement:  "struct address student[100];"  will allocate memory
22    space for 100 structures of type "address".  Each of these structures
22    can now be accessed by using an array index and the structure member
22    operator (.).
22
22    For example:
22
22    student[49].zip  will access the variable "zip" of the 50th structure
22                     (of type "address") in the array "student".
22
22    student[9].city = "New York";  will assign the character string "New
22                                   York" to the character array "city" of
22                                   the 10th structure (of type "address")
22                                   in the array "student".
23B:330
21Frame 330 QP
22Given the declaration:  struct name {
22                           char f_name[F_SIZE];
22                           char m_init;
22                           char l_name[L_size];
22                        } roster[50];
22
22A "template" structure of type "name" is declared and an array of 50 of these
22structures called "roster" is declared as well.  (True or False)
23Y
24 Very good.
24 B:335
25 Wrong.  This is one way we have seen to combine the two methods of struc-
25 ture declaration.
25 B:335
21Frame 335 T
22    *** Topic Review ***
22
22    In this topic we have looked at how structures are declared and used
22    within other structures and we saw how to declare and use an array
22    of structures.
```

```
22
22    Although we didn't look at very many or very involved examples of the
22    uses of these two capabilities, I think that it is enough to introduce
22    you to their use and will spark your ingenuity for programming appli-
22    cations. The rest of this lesson will discuss some other ways of work-
22    ing with structures in C programming.
22
22    In the next topic area (3) I will describe and show examples of how
22    to use pointers to structures.  In topic area four I will discuss
22    how to pass structure data between functions.
22
22                    *** This concludes this topic area. ***
23END
31Frame 500 T  Structures and Pointers
32    *** Introduction ***
32
32    In lesson four we saw that a "pointer" is actually a variable that con-
32    tains the address of where some other variable resides in memory.
32
32    In this topic area I will describe how pointers are used to access
32    structures and their members.  We will take a look at a couple examples
32    to help see this fairly straightforward technique.
32
32    Let's get started!
33B:505
31Frame 505 T
32    *** Pointers to Structures ***
32
32    We have seen that given a structure declaration such as:
32
32    struct income {
32       float gross;
32       float fitw;
32       float s_tax;
32       float fica;
32    } pay;
32
32    This declares a "template" structure of type "income" and also declares
32    a variable "pay" to be of that type.
32
32    As we have seen, we can now access the individual members of the vari-
32    able "pay" by using the "structure member operator" (.).  For example:
32    pay.gross will access the variable "gross" within the structure "pay".
33B:510
31Frame 510 T
32    * Pointers to Structures Continued *
32
32    Let's now look at how we can use pointers to access the structure and
32    its members.
32
32    Given the structure declaration:  struct income {
```

```
32                                        float gross;
32                                        float fitw;
32                                        float s_tax;
32                                        float fica;
32                                      } pay;
32
32    We can use the pointer declaration:  struct income *p_pay;  to declare
32    a pointer "p_pay" that points to a structure of type "income".
32
32    Using the statement:  p_pay = &pay;  we assign the starting address of
32    variable "pay" (of structure type "income") to variable "p_pay".
33B:515
31Frame 515 QM
32Given the structure declaration:  struct address {
32                                     char street[S_SIZE];
32                                     char city[C_SIZE];
32                                     long zip;
32                                   } home;
32
32Which of the following will assign the starting address of the structure
32"home" to the pointer "p_home" ?
33A  p_home = home;
33B  p_home = address;
33C+ p_home = &home;
33D  p_home = &address;
34 Right.
34 B:520
35ABD Wrong.  Response "C" is the correct one.
35 B:520
35E "E" was not a given choice.  Please try again.
35 B:515
31Frame 520 T
32    * Pointers to Structures Continued *
32
32    Now that we have defined a pointer to the structure "pay", we need to
32    learn how to use this pointer to access the members of the structure.
32
32    The way in which this is done in C is through the use of the a special
32    operator which is composed of a minus and greater than sign "->".
32
32    For example, if we wish to access the variable "gross" of the structure
32    "pay" in our example, we could use the expression:  p_pay->gross
32
32    This, of course, would be used in a statement such as:
32
32    p_pay->gross = gross_pay;  which would store the value of "gross_pay"
32    in the memory location represented by "gross" within structure "pay".
33B:525
31Frame 525 T
32    * Pointers to Structures Continued *
32
```

```
32    The special operator  ->  is provided as a shorthand way of accomplish-
32    ing the same thing that the unary operator  *  does.
32
32    The statement we just saw, p_pay->gross = gross_pay; , could have been
32    just as easily written as:  (*p_pay).gross = gross_pay;  and would
32    have the same result.
32
32    The problem with using the unary operator  *  (asterisk) is that it
32    has a lower precedence than the structure member operator  .  (period).
32    Hence, you must use parentheses to ensure proper execution.
32
32    With this in mind it is easy to see that using the provided special
32    operator  ->  is easier and clearer.
33B:530
31Frame 530 QP
32Given the structure declaration:  struct address {
32                                    char street[S_SIZE];
32                                    char city[C_SIZE];
32                                    long zip;
32                                  } home;
32
32The variable "zip" can be accessed by using the expression:  p_home->&zip
32Provided "p_home" has been declared a pointer to type "address".
32(True or False)
33N
34 Very good.  The correct expression is:  p_home->zip.
34 B:535
35 No.  The correct expression is:  p_home->zip.
35 B:535
31Frame 535 T
32    * Pointers to Structures Continued *
32
32    As a quick review.
32
32                                 |                              |  You can access
32    If you have a structure      |  And a pointer variable      |  the individual
32    declaration like:            |  declaration like:           |  structure members
32                                 |                              |  with expressions:
32    ---------------------------------------------------------------------------
32    struct income {              |  struct income *p_pay;       |  p_pay->gross
32       float gross;              |  p_pay = &pay;               |  p_pay->fitw
32       float fitw;               |                              |  p_pay->s_tax
32       float s_tax;              |                              |  p_pay->fica
32       float fica;               |                              |
32    } pay;                       |                              |
33B:540
31Frame 540 T
32    *** Topic Review ***
32
32    In this topic area we have looked at how pointers to structures are
32    declared and how to access the individual members of a structure
32    using a declared pointer.
```

```
32
32    We have seen a couple examples to help illustrate this technique.
32
32    In the next topic area I will describe how to pass structure data
32    between functions.
32
32    Hope to see you there!
32
32
32                    *** This concludes this topic area. ***
33END
41Frame 700 T  Structures and Functions
42    *** Introduction ***
42
42    In this topic area I will describe how structure data is passed between
42    functions.
42
42    We have seen already how to pass variables as well as pointers between
42    functions.  Passing structure data is done in much the same way.  We
42    will look at a few examples to help illustrate this concept.
42
42
42    Let's get started!
43B:705
41Frame 705 T
42    *** Passing Structure Data ***
42
42    Using the structure we defined in the last topic area:
42
42    struct income {
42       float gross;
42       float fitw;
42       float s_tax;
42       float fica;
42    } pay;
42
42    One way to pass the data contained in the structure to a called func-
42    tion is to pass the structure members individually.  For example:
42
42    compute(pay.gross,pay.fitw,pay.s_tax,pay.fica);
42
42    Calls function "compute" and passes the four members of structure "pay".
43B:710
41Frame 710 T
42    * Passing Structure Data Continued *
42
42    The called function would look something like the following in order
42    to receive and use the passed variables:
42
42    float compute(gross,fitw,s_tax,fica)
42       float gross,fitw,s_tax,fica;
```

```
42    {
42       take_home_pay = gross - (fitw + s_tax + fica);
42       return(take_home_pay);
42    }
43B:715
41Frame 715 T
42    * Passing Structure Data Continued *
42
42    A second way to pass the structure data to the called function is to
42    pass the entire structure.  For example:
42
42    compute(pay);  will pass the address of the beginning of structure
42                   "pay" to function "compute".
42
42    The called function would look something like the following in order
42    to receive and use the passed structure address.
42
42    float compute(p_data)
42       struct income p_data;
42    {
42       t_h_p = p_data.gross - (p_data.fitw + p_data.s_tax + p_data.fica);
42       return(t_h_p);
42    }
43B:720
41Frame 720 T
42    * Passing Structure Data Continued *
42
42    A third way to pass the structure data to the called function is to
42    pass a pointer to the structure.  For example, if you have a structure
42    defined as:
42                 struct income {
42                    float gross;
42                    float fitw;
42                    float s_tax;
42                    float fica;
42                 } pay;
42
42    Define a pointer variable with the statement:  struct income *p_pay;
42
42    Assign the address to the pointer variable:  p_pay = &pay;
42
42    Then call the function:  compute(p_pay);
43B:725
41Frame 725 T
42    * Passing Structure Data Continued *
42
42    The called function would look something like the following in order
42    to receive and use the passed pointer variable:
42
42    float compute(pntr)
42       struct income *pntr;
```

```
42    {
42       t_h_p = pntr->gross - (pntr->fitw + pntr->s_tax + pntr->fica);
42       return(t_h_p);
42    }
43B:730
41Frame 730 QM
42Which of the following is not one of the three ways of passing structure
42data to a called function?
43A  Pass structure members individually.
43
43B+ Pass the structure template name.
43
43C  Pass the entire structure.
43
43D  Pass a pointer to the structure.
44 Your right.
44 B:735
45ACD Wrong.  Answer "B" is not a valid way to pass structure data.
45 B:735
45E "E" was not a give choice.  Please try again.
45 B:730
41Frame 735 T
42    *** Lesson Five Summary ***
42
42    Well, we have come to the end of lesson five.  If you have seen the
42    four subject topics in this lesson, you should now be ready to take
42    the final test.  If you feel that you don't understand something well
42    enough to pass the test, please retake the topic that is giving you
42    problems.
42
42    Topic 1 gave an introduction to structures and their use.
42
42    Topic 2 gave a description of structures within structures and arrays
42    of structures.
42
42    Topic 3 gave a description of how pointers to structures are used.
42
42    Topic 4 described how structure data is passed between functions.
43END
51Frame 900 TT TEST OVER LESSON 5
52    Welcome to the final test of lesson five.  This test consists of seven
52    questions over material presented in the previous four topic areas.
52
52    In order to successfully complete this lesson, you must achieve a
52    minimum score of 71.4% (five out of seven questions correct).
52
52    If you miss a question, the correct answer will not be shown.  It is
52    up to you to research the correct answer.
52
52    Well, enough said.  Let's get on with it.  Good luck!
53B:905
```

```
51Frame 905 QM
521.  Which of the following can be used to declare a structure?
53A  struct structure_tag { variable declarations };
53B  struct; { variable declarations }; structure name;
53C  struct { variable declarations } structure name;
53D  None of the above.
53E+ Both "A" and "C" above.
54 Right.      (1,110 & 125)
54 B:910
55ABCD Wrong.      (1,110 & 125)
55 B:910
51Frame 910 QM
522.  Given the structure declaration:  struct houses {
52                                         int num_wood;
52                                         int num_brick;
52                                         int num_stucco;
52                                       } resident;
52
52Which of the following is a way to access the variable "num_brick" ?
53A  houses.num_brick
53B  houses.resident.num_brick
53C+ resident.num_brick
53D  resident.houses.num_brick
54 Right.      (1,135-140)
54 B:915
55ABD Wrong.      (1,135-140)
55 B:915
55E "E" was not one of your choices.
55 B:910
51Frame 915 QP
523.  In the C programming language there is no provision for the use of
52structures within structures because it would require to much memory
52overhead.  (True or False)
53N
54 Right.      (2,305)
54 B:920
55 Wrong.      (2,305)
55 B:920
51Frame 920 QM
524.  Given the structure declaration:  struct address {
52                                         char street[S_SIZE];
52                                         char city[C_SIZE];
52                                         long zip;
52                                       };
52
52Which of the following is a way to declare an array of 50 such structures?
53A  array_of_address struct address[50];
53B+ struct address array_of_address[50];
53C  struct array_of_address address[50];
53D  address[50] struct array_of_address;
54 Right.      (2,320-325)
54 B:925
```

```
55ACD Wrong.      (2,320-325)
55 B:925
51Frame 925 QP
525.  Given the structure declaration:  struct address {
52                                         char street[S_SIZE];
52                                         char city[C_SIZE];
52                                         long zip;
52                                       } home;
52
52And the pointer declaration:  struct address *p_home;
52
52The statement:  p_home = &home;  will assign the starting address of the
52structure "home" (of type "address") to the pointer "p_home".
52(True or False)
53Y
54 Right.      (3,510)
54 B:930
55 Wrong.      (3,510)
55 B:930
51Frame 930 QM
526.  Given the declaration:  struct name {
52                                  char f_name[F_SIZE];
52                                  char m_init;
52                                  char l_name[L_size];
52                                } roster[50];
52
52Which of the following expressions can be used to access the variable
52"m_init" (Assume pointer "p_roster" has been properly declared.)?
53A+ p_roster->m_init
53B  p_roster->&m_init
53C  p_roster->roster.m_init
53D  p_roster->name->roster.m_init
54 Right.      (3,515)
54 B:935
55BCD Wrong.      (3,515)
55 B:935
55E "E" was not one of your choices.
55 B:930
51Frame 935 QM
527.  Which of the following is not one of the three ways of passing structure
52data to a called function?
53A  Pass structure members individually.
53B  Pass the entire structure.
53C+ Pass the structure template name.
53D  Pass a pointer to the structure.
54 Right.      (4,705,715,720)
54 B:940
55ABE Wrong.      (4,705,715,720)
55 B:940
55E "E" was not one of your choices.
55 B:935
```

```
51Frame 940 T
52    *** End of Lesson Material ***
52
52    This marks the end of lesson number five.  I hope that it was of some
52    benefit to you.  I am looking forward to seeing you in lesson number
52    six.  I hope that you didn't have too much trouble with the material
52    presented in this lesson.  If you did, please voice your comments to
52    your training monitor who will in turn contact the CAI Plans Branch
52    at Keesler AFB, MS.
52
52    Well, let's take a look at how you did with the test ...
53END
```

File "LESSON6"

```
#      WW     WW  EEEEEEEE  LL          CCCCCCC   000000   MMM   MMM  EEEEEEEE
#      WW WW WW   EE        LL        CC         00    00  MMM   MMM  EE
#      WW WW WW   EEEEE     LL        CC         00    00  MM MM MM  EEEEE
#      WWW   WWW  EE        LL        CC         00    00  MM MM MM  EE
#      WWW   WWW  EEEEEEEE  LLLLLLLL   CCCCCCC   000000   MM    MM  EEEEEEEE
#
#
#                              TTTTTTTTTT    00000000
#                                  TT       00      00
#                                  TT       00      00
#                                  TT       00      00
#                                  TT        00000000
#
#
#      LL         EEEEEEEE   SSSSSS    SSSSSS    000000   NN     NN        6666
#      LL         EEEEEEEE  SSSSSSSS  SSSSSSSS  00000000  NNN    NN       6666
#      LL         EE        SSS       SSS       00    00  NNNN   NN      666
#      LL         EEEEE      SSSS      SSSS     00    00  NN NN  NN     666
#      LL         EEEEE        SSSS      SSSS   00    00  NN NN  NN     6666666
#      LL         EE             SSS       SSS  00    00  NN  NNNN     666   66
#      LLLLLLLL   EEEEEEEE  SSSSSSSS  SSSSSSSS  00000000  NN   NNN      666 666
#      LLLLLLLL   EEEEEEEE   SSSSSS    SSSSSS    000000   NN    NN       66666
#
#  THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INTRODUCTORY INFORMATION ON
#  INPUT AND OUTPUT CAPABILITIES OF THE  C  PROGRAMMING LANGUAGE.
#
#  THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.
#
#
#  The Lesson Breakdown Is As Follows:
#
#  Topic 1:  Getchar and Putchar - This topic gives a description of the use
#            of the standard I/O functions "getchar" and "putchar".
#            (Approx. time = 5 min.)
#
#
#  Topic 2:  Getline - This topic gives a description of the use of the stan-
#            dard input function "getline" and presents an example "getline"
#            function.  (Approx. time = 5 min.)
#
#
#  Topic 3:  Scanf - This topic gives a description and examples of the stan-
#            dard input function "scanf".  (Approx. time = 15 min.)
#
#  Lesson Breakdown Continued:
#
#  Topic 4:  Printf - This topic gives a description and examples of the stan-
#            dard output function "printf".  (Approx. time = 10 min.)
#
#
```

```
#  Topic 5:  Lesson 6 Test - This is the lesson test over items that have
#            been presented in the previous four lesson topics.
#            (Approx. time = 5 min.)
#
#
#  TOTAL LESSON TIME IS APPROXIMATELY 40 MINUTES.
#
#
#  I hope that you enjoy it!
:
*****************************************************************************
*                                                                           *
*             SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:         *
*                                                                           *
*****************************************************************************
*                                                                           *
*     STATUS          TOPIC #           TOPIC TITLE                         *
*     ------          -------           -----------                         *
*                                                                           *
@                        1              Getchar and Putchar                 *
*                                                                           *
@                        2              Getline                             *
*                                                                           *
@                        3              Scanf                               *
*                                                                           *
@                        4              Printf                              *
*                                                                           *
@                        5              Test Over Lesson 6                  *
*                                                                           *
*****************************************************************************
*      NOTE:  A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.     *
*****************************************************************************
11Frame 100 T  Getchar and Putchar
12    *** Introduction ***
12
12    Input/Output (I/O) is "not" a part of the C programming language.
12    Statements such as Print, Write, or Read are "not" available for use.
12
12    The way in which you compensate for C's lack of I/O capability is to
12    make use of library functions supplied by the C compiler's manufacturer.
12
12    The types of functions that are provided with a specific C compiler
12    vary from manufacturer to manufacturer, so it is suggested that you
12    review your C compiler's documentation in order to determine what
12    functions you can make use of.
12
12    In this topic area we will take a look at some basic I/O functions
12    that most manufacturers provide.
13B:105
11Frame 105 T
12    * Introduction Continued *
12
```

12 In order for you to have access to the standard I/O functions provided with your C compiler you may need to include a header file that contains the definitions and declarations needed by the I/O functions.
12
12 The file name that you include depends on the compiler you are using. Typically the include statement will look something like the following:
12
12 #include <stdio.h> OR #include <bdscio.h>
12
12 Please check your compiler's documentation for the proper header file to be included, if any.
12
12 In this lesson topic we will be discussing how to use the standard I/O functions "getchar" and "putchar". We will see examples of how these two functions are called and what they do. Let's get started.
13B:110
11Frame 110 T
12 *** Getchar ***
12
12 The function "getchar" is used to read one character at a time from the standard input device. The standard input device is by default the users terminal keyboard.
12
12 Note: The standard input device can be changed on most systems, but how this is done will not be discussed in this course.
12
12 The format of the call to the function "getchar" is as follows:
12
12 c = getchar(); Where "c" is any variable of type "int".
12
12 What was that? Variable "c" is of type "int"! Well, that just doesn't sound right. Let's look at this a little closer.
13B:115
11Frame 115 T
12 * Getchar Continued *
12
12 The requirement that the variable that receives the character returned by the function "getchar" be of type "int" stems from the fact that "getchar" is a function that returns an integer value.
12
12 The only time you would run into problems in making the variable "c" a "char" type is if you were trying to detect an end of file condition. The reason for this is that EOF is typically equal to -1, which is of course an integer.
12
12 Thus, when the EOF is encountered it must be read into a variable of type "int".
13B:120
11Frame 120 T
12 * Getchar Continued *
12
12 For example, the following program will "not" work.

```
12
12       main() {
12         char c;
12         while ((c = getchar()) != EOF)
12           < some statement to deal with variable "c" >;
12       }
12
12    The proper way to write the program is:
12
12       main() {
12         int c;
12         while ((c = getchar()) != EOF)
12           < some statement to deal with variable "c" >;
12       }
13B:125
11Frame 125 T
12    * Getchar Continued *
12
12    As another example, the following program will work since no check is
12    made against "EOF".
12
12       main() {
12         char c;
12         while ((c = getchar()) != '\n')
12           < some statement to deal with variable "c" >;
12       }
12
12    Here the terminating condition is when "c" is equal to the "newline"
12    C escape sequence.  As you can see, the requirement for the receiving
12    variable of the function "getchar" to be of type "int" is not without
12    exception.  Just be aware of the fact that "getchar" returns an "int"
12    type and this may cause you a problem if the receiving variable is not
12    of the same type.
13B:130
11Frame 130 QP
12The "getchar" function is used to read one character at a time from standard
12input to the executing C program.  (True or False)
13Y
14 Right.
14 B:135
15 Wrong.  Wake up!
15 B:135
11Frame 135 T
12    *** Putchar ***
12
12    The function "putchar" is used to write one character at a time to
12    the standard output device.  The standard output device is by default
12    the users terminal screen.
12
12    Note:  The standard output device can be changed on most systems, but
12    how this is done will not be discussed in this course.
12
```

```
12    The formats of the call to the function "putchar" is as follows:
12
12       putchar(c);      Where  c  is any character variable.
12
12       putchar('c');    Where  'c'  is any character constant.
12
12       putchar('\c');   Where  \c  is any C escape sequence.
13B:140
11Frame 140 T
12    * Putchar Continued *
12
12    For example:
12
12       main() {
12         putchar('I');
12         putchar(' ');
12         putchar('l');
12         putchar('i');
12         putchar('k');
12         putchar('e');
12         putchar(' ');
12         putchar('C');
12         putchar('.'); }
12
12    This program will write the sentence:  I like C.  to the standard
12    output device (terminal screen).
13B:145
11Frame 145 T
12    * Putchar Continued *
12
12    As another example:
12
12       main() {
12         char string[] = "I like C.";
12         for (i = 0; string[i] != '\0'; i++)
12           putchar(string[i]);
12       }
12
12    This program will also write the sentence:  I like C.  to the standard
12    output device (terminal screen).  The loop terminating expression will
12    become "true" when the end-of-string marker (\0) is encountered.
13B:150
11Frame 150 QM
12Which of the following is "not" a correct way to use the "putchar" function?
13A   putchar(c);      Where  c  is any character variable.
13B+  putchar(*c);     Where  *c  is a pointer to any character array.
13C   putchar('c');    Where  'c'  is any character constant.
13D   putchar('\c');   Where  \c  is any C escape sequence.
14 Very good.
14 B:155
15ACD No.  Answer "B" is the correct one.
15 B:155
```

```
15E "E" was not a given choice.  Please try again.
15 B:150
11Frame 155 T
12    *** Combination Example ***
12
12    This example shows how you can combine both the "getchar" and "putchar"
12    functions to read & write a line of text from/to the standard I/O
12    device.
12
12       main() {
12         char c;
12         while ((c = getchar()) != '\n')
12           putchar(c);
12       }
12
12    This program will terminate when the user hits the "Return" key at the
12    end of his/her typed line.
13B:160
11Frame 160 T
12    *** Topic Review ***
12
12    In this topic we have looked at the standard I/O functions "getchar"
12    and "putchar".
12
12
12    We have seen a few examples of how to access and use these functions
12    and discussed a couple of things to be aware of in their use.
12
12
12    In the next topic area I will describe the I/O function "getline" and
12    give a few examples of its use.
12
12    See you there!
12
12
12                    *** This concludes this topic area. ***
13END
21Frame 300 T  Getline
22    *** Introduction ***
22
22    In this topic area I will describe the I/O function "getline".
22
22    This function is used to read in one line of input from the standard
22    input device (users terminal keyboard).  In addition to reading a
22    line of input, the "getline" function also keeps track of how many
22    characters were read in.
22
22    We saw in the last topic area how to accomplish the reading of a line
22    of input using the "getchar" function, but as you can well imagine, if
22    you need to do this task in several points in your program it would pay
22    to have a seperate function defined which you could call.
22
```

```
22    Most C compilers have this function as part of its I/O library, but
22    just in case your compiler manufacturer didn't include it, I will
22    present a version of "getline" that you can use in your programs.
23B:305
21Frame 305 T
22    *** Getline ***
22
22    The format of the call to the function "getline" is as follows:
22
22       n = getline(input_line,80);
22
22    Where "n" is any variable of type "int", "input_line" is a character
22    array, and "80" is the maximum length of the array. When the above
22    statement is executed the "getline" function will read a line of input
22    from the users terminal keyboard. The above call will read in at most
22    78 characters.  If the user were to type 78 characters and then hit the
22    "Return" key, the actual contents of the "input_line" array would be as
22    follows:
22
22       input_line[0] thru input_line[77] = characters  (78 characters)
22       input_line[78] = \n  (end of line character)
22       input_line[79] = \0  (end of string marker)
23B:310
21Frame 310 T
22    * Getline Continued *
22
22    As I stated before, the "getline" function will keep track of the
22    number of characters it reads in.  What I didn't mention is that
22    it will return this number to the calling function if so desired.
22
22    In our example statement:  n = getline(input_line,80);
22
22    The variable "n" (of type "int") is where the number of characters
22    read in is stored.  This number will include the 78 characters of
22    user input and the end of line character, but not the end of string
22    marker.  For our example this would give us a total count of 79.
22
22    How you use this number, if at all, depends on your programs applica-
22    tion.
23B:315
21Frame 315 QM
22Given the function call statement:  n = getline(input_line,80);
22
22Which of the following is "not" true.
23A   "n" must be a variable of type "int".
23B+  "getline" will return two values "n" and "input_line".
23C   "input_line" must be a character array.
23D   "80" is the maximum input line size.
24 Right.  "getline" will return an integer value to "n", but the array
24 "input_line" is passed as a pointer to array position input_line[0].
24 B:320
25ACD Wrong.  Answer "B" is the correct response.  "getline" will return an
```

```
25 integer value to "n", but the array "input_line" is passed as a pointer to
25 array position input_line[0].
25 B:320
25E "E" was not a given choice, please try again.
25 B:315
21Frame 320 T
22    * Getline Continued *
22
22    Let's take a look at a sample program that uses the function "getline".
22
22       main() {
22         char input_line[80];
22         getline(input_line,80);
22         i = 0;
22         while (input_line[i] != '\0') {
22           putchar(input_line[i]);
22           i++;
22         }
22       }
22
22    This program will read in one line of input from the users terminal
22    keboard and print the stored line (one character at a time) on the
22    users terminal screen.
23B:325
21Frame 325 T
22    * Getline Continued *
22
22    Now that we have seen how to use the "getline" function that is usually
22    provided with your C compiler by the manufacturer, let's take a look at
22    how you can define your own version of the "getline" function.
22
22
22    The following will perform the same as the "getline" function we have
22    just looked at and can be included in your programs if the "getline"
22    function is not available.
23B:330
21Frame 330 T
22    * Getline Continued *
22
22    getline(in_ln,max)
22      char in_ln[];
22      int max;
22    {
22      int i,c;
22      for (i = 0; i < (max-1) && (c = getchar()) != EOF && c != '\n'; i++)
22         in_ln[i] = c;
22      if (c == '\n')
22        in_ln[i++] = c;
22      in_ln[i] = '\0';
22      return(i);
22    }
23B:335
```

```
21Frame 335 QP
22Given the function call statement:  getline(input_line,35);
22
22The maximum number of characters that will be read by the function "getline"
22is 35.  (True or False)
23N
24 Very good.  34 characters can be read.  One character is used to store the
24 end of string marker.
24 B:340
25 Wrong.  34 characters can be read.  One character is used to store the
25 end of string marker.
25 B:340
21Frame 340 T
22    *** Topic Review ***
22
22    In this topic we have looked at the I/O function "getline" which may
22    or may not be included with your C compiler's standard I/O library.
22
22    We have seen a few examples of how to access and use this function
22    and we saw a version of the function that you can include in your
22    program if it is not available with your compiler.
22
22
22    In the next topic area I will describe the I/O function "scanf" and
22    give a few examples of its use.
22
22    See you there!
22
22
22                    *** This concludes this topic area. ***
23END
31Frame 500 T  Scanf
32    *** Introduction ***
32
32    In this topic area I will describe the I/O function "scanf".
32
32    This function is used to read characters from the standard input
32    device (users terminal keyboard) and do some sort of conversion on
32    the read characters.  In essence the function is used to do format-
32    ted input.
32
32    We saw in the last topic area how to accomplish the reading of a line
32    of input using the "getline" function, but if the input you wish to
32    read is not composed of just characters you would be hard put to store
32    the input in their intended form.
32
32    All C compilers should have the function "scanf" as part of its I/O
32    library.  Please check your compiler's documentation to be sure of
32    this functions availability.
33B:505
31Frame 505 T
32    *** Scanf ***
```

```
32
32    The format of the "scanf" function call is composed of two parts:
32    a format control string and the pointer arguments.
32
32    A skeleton of the function call looks like this:
32
32       scanf("format control string", &arg_1, &arg_2, ..., &arg_n);
32
32    The format control string will be described in detail shortly.  The
32    arguments following the string must be pointers to the memory loca-
32    tions where the read in arguments are to be stored.
32
32    It is a fairly common mistake to try and read values into a variable
32    by just specifying the variable name.  This can not be done since
32    "scanf" is a function and as such can only return one value. Thus,
32    you must somehow pass it the address of where the variable is stored.
33B:510
31Frame 510 T
32    * Scanf Continued *
32
32    The format control string will usually contain the conversion speci-
32    cations to be applied to the input sequences read from the input
32    device.
32
32    The format control string begins with a percent sign (%) and ends
32    with either a conversion character or character class.
32
32    The following is a verbal description of what is allowed for use in
32    the format control string:
32
32    A "percent sign" followed by an "argument suppression character"
32    followed by an "integer field width specifier" followed by a "length
32    modification character" followed by a "conversion character or char-
32    acter class".
33B:515
31Frame 515 QP
32The format of the "scanf" function call is composed of two parts:
32a "format control string" and the "pointer arguments".  (True or false)
33Y
34 Right.  I'm glad your paying attention.
34 B:520
35 Wrong.  That is a true statement.
35 B:520
31Frame 520 T
32    * Scanf Continued *
32
32    Let's now look at each part of the "format control string" of the
32    scanf function call.
32
32    The "format control string" is made up of individual conversion
32    specifications.  Each of these conversion specifications "must"
32    begin with a "percent sign" (%).
```

```
32
32    The next (optional) character is an "argument suppression character".
32    This character is an asterisk (*) and indicates that the next input
32    field is to be skipped.  Thus, no assignment is made into the corre-
32    sponding input argument.
32
32    The next (optional) part of the "string" is an "integer field width
32    specifier" which is used to specify the maximum field width of the
32    input.
33B:525
31Frame 525 T
32    * Scanf Continued *
32
32    The next (optional) part of the "string" is the "length modification
32    character".  This character can be one of two letters:  l or h .
32    These two letters can only be used in conjunction with certain "con-
32    version characters" as will be described forthwith.
32
32    The last part of the "string" is the "conversion character or char-
32    acter class".  The "conversion character" can be one of 13 different
32    characters.
32
32    I will now give a brief description of each of these characters.
33B:530
31Frame 530 T
32    * Scanf Continued *
32
32    d = decimal integer (argument should point to "int" variable type.)
32    o = octal integer (argument should point to "int" variable type.)
32    x = hexadecimal integer (argument should point to "int" variable type.)
32
32    D = decimal integer (argument should point to "long" variable type.)
32    O = octal integer (argument should point to "long" variable type.)
32    X = hexadecimal integer (argument should point to "long" variable type.)
32
32    e or f = floating point number (argument should point to "float" vari-
32             able type.)
32
32    E or F = floating point number (argument should point to "double" vari-
32             able type.)
33B:535
31Frame 535 T
32    * Scanf Continued *
32
32    c = character (argument should point to "character" variable type.)
32
32    s = string (argument should point to "character array" variable type.)
32
32    % = percent sign is expected as the next input character.
32
32    As a refresher:  Integer input:  d, o, x, D, O, or X
32
```

```
32                      Floating point input:  e, f, E, or F
32
32                      Character input:  c
32
32                      String input:  s
32
32                      Percent sign input:  %
33B:540
31Frame 540 T
32    * Scanf Continued *
32
32    Let's look at a couple of examples involving the "scanf" function call.
32
32        scanf("%d%f",&int_var,&float_var);
32
32    The above call will read from standard input (users terminal keyboard)
32    two numbers of the types "integer" and "floating point real".
32
32    The users typed input numbers would be of the form:  23 45.78
32
32    The "scanf" function will read into the first aurgment ("int_var")
32    until a "white space" character or a character that is incompatiable
32    with the specified "format control string" is encountered.
32
32    Note:  A "white space" character is defined as a "blank", "tab" (\t),
32    or "newline" (\n).
33B:545
31Frame 545 T
32    * Scanf Continued *
32
32    As another example:  scanf("%s%*c%d%%",s_array,&int_var);
32
32    This "scanf" call will read a "string", "integer", and "percent sign".
32
32    The users input would look something like this:  Tax = 5%
32
32    The function "scanf" will read the word "Tax" into the array "s_array",
32    then skip the character "=", then read the integer "5", and finally
32    read the "percent sign".  No space is needed after the "5" in the users
32    input since the "percent sign" is not compatiable with the "%d" format
32    control string.  The "percent sign" is not stored anywhere.
33B:550
31Frame 550 QM
32Given the function call:  scanf("%d%f%s%c",&w,&x,y,&z);
32
32Which of the following variables will contain a number with a decimal point?
33A   w
33B+  x
33C   y
33D   z
34 Right.
34 B:555
```

```
35ACD Wrong.  Response "B" is the correct answer.
35 B:555
35E "E" was not one of your choices, please try again.
35 B:550
31Frame 555 T
32    * Scanf Continued *
32
32    One more point on the "format control string" that I promised to
32    talk about, namely the "length modification character".
32
32    As I mentioned, this optional character can be either the letter
32    l or the letter h.  The "length modification character" can only
32    be used with certain "conversion characters".
32
32    You may use the letter l with the conversion characters d, o, or x
32    to indicate that the value being read in is to be stored in a "long"
32    rather than "int" variable type.  i.e., scanf("%ld",&l_int);
32
32    You may use the letter h with the conversion characters d, o, or x
32    to indicate that the value being read in is to be stored in a "short"
32    rather than "int" variable type.  i.e., scanf("%hd",&s_int)
33B:560
31Frame 560 T
32    * Scanf Continued *
32
32    As I mentioned during the description of the format of the "scanf"
32    function call, the "format control string" begins with a percent sign
32    and ends with either a "conversion character" or "character class".
32
32    We have seen what the "conversion character" is, but we still need
32    to cover the "character class".
32
32    A "character class" is identified by a set of brackets [] following
32    the percent sign.  The "character class" is used in conjunction with
32    a character array argument.
32
32    Let's look at two examples to demonstrate the use of "character class".
33B:565
31Frame 565 T
32    * Scanf Continued *
32
32       Example #1:  scanf("%[abcdefghijklm]",valid_letters);
32
32    In this example an input string is read until a letter is encountered
32    that "is not" in the "character class" specified.  The character array
32    "valid_letters" must be big enough to hold the read in input string.
32
32       Example #2:  scanf("%[^abcdefghijklm]",valid_letters);
32
32    An alternate form of the "character class" uses a circumflex (^).
32    When this form is used, the valid input becomes any character not
32    specified in the "character class".  Therefore, for example #2 above,
```

```
32    the input string will be read until a letter is encountered that "is"
32    in the "character class" specified.
33B:570
31Frame 570 T
32    *** Topic Review ***
32
32    In this topic we have looked at the I/O function "scanf" which is
32    usually included with your C compiler's standard I/O library.
32
32    We have seen a few examples of how to access and use this function
32    and discussed many of the special features of the function.
32
32
32    In the next topic area I will describe the I/O function "printf" and
32    give a few examples of its use.
32
32    See you there!
32
32
32                    *** This concludes this topic area. ***
33END
41Frame 700 T  Printf
42    *** Introduction ***
42
42    In this topic area I will describe the I/O function "printf".
42
42    This function is used to convert and print specified arguments to
42    the standard output device (users terminal screen).  In essence the
42    function is used to do formatted output.
42
42    We saw in the last topic area how to accomplish formatted input by
42    using the "scanf" function.  We will now cover how to accomplish the
42    task of producing output from your C program in any form you like.
42
42    All C compilers should have the function "printf" as part of its I/O
42    library.  Please check your compiler's documentation to be sure of
42    this functions availability.
43B:705
41Frame 705 T
42    *** Printf ***
42
42    The format of the "printf" function call is composed of two parts:
42    a format control string and the arguments.
42
42    A skeleton of the function call looks like this:
42
42       printf("format control string", arg_1, arg_2, ..., arg_n);
42
42    The format control string will be described in detail shortly.
42    The arguments following the string have two important restrictions:
42
42       1. Their "type" must agree with the corresponding conversion
```

```
42       control character within the "format control string".
42
42       2. The number of arguments must agree with the number of con-
42       version control specifications in the "format control string".
43B:710
41Frame 710 T
42    * Printf Continued *
42
42    The format control string will usually contain the conversion speci-
42    cations to be applied to the output sequences being printed to the
42    output device.
42
42    However, you may also use the "printf" function to print character
42    sequences "character for character".
42
42    For example:  printf("C is GREAT");  will print:  C is GREAT
42
42    The format control string usually begins with a percent sign (%) and
42    ends with a conversion character, but can begin with C character es-
42    cape sequences.
42
42    For example:  printf("\n\t%d",arg_1);  will execute a "new line" and
42                                            a "tab", then print an integer.
43B:715
41Frame 715 QP
42The "printf" function call:  printf("\nI Love C");  will execute a "new line"
42and then print the character sequence:  I Love C    (True or false)
43Y
44 Right.  Good work!
44 B:720
45 Sorry, that is a true statement.
45 B:720
41Frame 720 T
42    * Printf Continued *
42
42    The following is a verbal description of what is allowed for use in
42    the "format control string" in addition to the "escape sequences".
42
42    A "percent sign" followed by a "minus sign" followed by an "integer
42    field width specifier" followed by a "period" followed by a "integer
42    precision specifier" followed by a "length modification character"
42    followed by a "conversion character".
42
42
42    Let's now look at each part of the "format control string" of the
42    "printf" function call.
43B:725
41Frame 725 T
42    * Printf Continued *
42
42    The "format control string" is made up of individual conversion
42    specifications.  Each of these conversion specifications "must"
```

```
42    begin with a "percent sign" (%).
42
42    The next (optional) character is a "minus sign".  The minus sign, if
42    present, indicates that the corresponding argument is to be printed
42    left justified in its field.  If no minus sign is present then the
42    argument is printed right justified.
42
42    The next (optional) part of the "string" is an "integer field width
42    specifier" which is used to specify the minimum field width in which
42    the converted argument is to be printed.
43B:730
41Frame 730 T
42    * Printf Continued *
42
42    The next (optional) part of the "string" is a "period".  The period
42    is used to seperate the "integer field width specifer" from the next
42    field of the "format control string".
42
42    The next (optional) part of the "string" is an "integer precision
42    specifier". This is used to specify the maximum number of digits to
42    be printed to the right of the decimal point (in the case of "double
42    and float" argument types) or the maximum number of characters (in
42    the case of a "character string" argument).
42
42    The next (optional) part of the "string" is the "length modification
42    character".  This character is the letter "l".  This letter can only
42    be used in conjunction with the "conversion characters":  d, u, o, x
43B:735
41Frame 735 T
42    * Printf Continued *
42
42    The last part of the "string" is the "conversion character".  The
42    "conversion character" can be one of 9 different characters.
42
42    d = signed decimal notation
42    u = unsigned decimal notation
42    o = unsigned octal notation
42    x = unsigned hexadecimal notation
42
42    f = float or double decimal notation (precision default = 6)
42    e = float or double scientific notation (precision default = 6)
42    g = float or double using the shorter of e or f above
42
42    s = string
42    c = character
43B:740
41Frame 740 T
42    * Printf Continued *
42
42    Let's look at a couple of examples involving the "printf" function call.
42
42        printf("%d %f",int_var,float_var);
```

```
42
42    The above call will print to standard output (users terminal screen)
42    two numbers of the types "integer" and "floating point real".
42
42    The users printed output numbers would be of the form:  23 45.78
42
42    The "printf" function will print the first aurgment ("int_var") and
42    then print the second argument ("float_var").
42
42    Note:  A "white space" or blank character is printed between the argu-
42    ments since one space appears between the conversion specifications
42    in the "format control string".
43B:745
41Frame 745 T
42    * Printf Continued *
42
42    As another example:  printf("\n%6.2f",float_var);
42
42    This "printf" call will execute a "new line" and then print a "float-
42    ing point real" right justified in a field of 6 print positions with
42    2 digits after the decimal point.
42
42    The users output would look something like this:  2561.89
42
42    The function "printf" will print the value in "float_var" using the
42    specified format unless more print positions are needed, in which
42    case, more print positions will be used.
43B:750
41Frame 750 QM
42Given the function call:  printf("%4d %-4.2f %s %c",w,x,y,z);
42
42Which of the following variables corresponds to the printed output:  HI
43A   w
43B   x
43C+  y
43D   z
44 Right.  HI  is a string.
44 B:755
45ABD Wrong.  HI  is a string, therefore response "C" is the correct answer.
45 B:755
41Frame 755 T
42    *** Lesson Six Summary ***
42
42    Well, we have come to the end of lesson six.  If you have seen the
42    four subject topics in this lesson, you should now be ready to take
42    the final test.  If you feel that you don't understand something well
42    enough to pass the test, please retake the topic that is giving you
42    problems.
42
42    Topic 1 gave a description of the I/O functions "getchar" and "putchar".
42
42    Topic 2 gave a description of the I/O function "getline".
```

```
42    Topic 3 gave a description of the I/O function "scanf".
42
42    Topic 4 gave a description of the I/O function "printf".
43END
51Frame 900 TT TEST OVER LESSON 6
52    Welcome to the final test of lesson six.  This test consists of seven
52    questions over material presented in the previous four topic areas.
52
52    In order to successfully complete this lesson, you must achieve a
52    minimum score of 71.4% (five out of seven questions correct).
52
52    If you miss a question, the correct answer will not be shown.  It is
52    up to you to research the correct answer.
52
52    Well, enough said.  Let's get on with it.  Good luck!
53B:905
51Frame 905 QP
521.  The "getchar" function is used to read one character at a time from
52standard input to the executing C program.  (True or False)
53Y
54 Right.      (1,110)
54 B:910
55 Wrong.      (1,110)
55 B:910
51Frame 910 QM
522.  Which of the following is "not" a correct use the "putchar" function?
53A   putchar(c);      Where  c  is any character variable.
53B+  putchar(*c);     Where  *c  is a pointer to any character array.
53C   putchar('c');    Where  'c'  is any character constant.
53D   putchar('\c');   Where  \c  is any C escape sequence.
54 Right.      (1,135)
54 B:915
55ACD Wrong.      (1,135)
55 B:915
55E "E" was not one of your choices.
55 B:910
51Frame 915 QM
523.  Given the function call statement:  n = getline(input_line,80);
52
52Which of the following is "not" true.
53A   "n" must be a variable of type "int".
53B+  "getline" will return two values "n" and "input_line".
53C   "input_line" must be a character array.
53D   "80" is the maximum input line size.
54 Right.      (2,305)
54 B:920
55ACD Wrong.      (2,305)
55 B:920
55E "E" was not one of your choices.
55 B:915
51Frame 920 QP
524.  Given the function call statement:  getline(input_line,35);
```

```
52
52The maximum number of characters that will be read by the function "getline"
52is 35.  (True or False)
53N
54 Right.      (2,310)
54 B:925
55 Wrong.      (2,310)
55 B:925
51Frame 925 QP
525.  The format of the "scanf" function call is composed of two parts:
52a "format control string" and the "pointer arguments".  (True or false)
53Y
54 Right.      (3,505)
54 B:930
55 Wrong.      (3,505)
55 B:930
51Frame 930 QM
526.  Given the function call:  scanf("%d%f%s%c",&w,&x,y,&z);
52
52Which of the following variables will contain a number with a decimal point?
53A   w
53B+  x
53C   y
53D   z
54 Right.      (3,530)
54 B:935
55ACD Wrong.      (3,530)
55 B:935
55E "E" was not one of your choices.
55 B:930
51Frame 935 QP
527.  The "printf" function call:  printf("\nI Love C");  will execute a "new
52line" and then print the character sequence:  I Love C    (True or false)
53Y
54 Right.      (4,710)
54 B:940
55 Wrong.      (4,710)
55 B:940
51Frame 940 T
52    *** End of Lesson/Course Material ***
52
52    This marks the end of lesson number six and hence the end of the
52    course.  I hope that the lesson as well as the course was of some
52    benefit to you.
52
52    I hope that you didn't have too much trouble with the material
52    presented in this or any of the lessons in this course.  If you
52    did, please voice your comments to your training monitor who will
52    in turn contact the CAI Plans Branch at Keesler AFB, MS.
52
52    Well, let's take a look at how you did with the test ...
53END
```

File "EXIT"

```
#  THE COURSE YOU ARE NOW LEAVING WAS WRITTEN BY CAPT FRANK DEMARCO
#  IN PARTIAL FULFILLMENT OF HIS MASTERS DEGREE IN INFORMATION SYSTEMS.
#
#
#
#   GGGGGG      000000      000000     DDDDDDD     BBBBBBB     YY     YY    EEEEEEEE
#  GGGGGGGG    00000000    00000000    DDDDDDDD    BBBBBBBB    YY     YY    EEEEEEEE
#  GG          00    00    00    00    DD    DD    BB    BB     YY   YY     EE
#  GG   GGG    00    00    00    00    DD    DD    BBBBBB        YYYY       EEEEEEE
#  GG    GG    00    00    00    00    DD    DD    BB    BB      YY        EE
#  GGGGGGGG    00000000    00000000    DDDDDDDD    BBBBBBBB      YY        EEEEEEEE
#   GGGGGGG     000000      000000     DDDDDDD     BBBBBBB       YY        EEEEEEEE
#
#
#  FFFFFFFF     000000     RRRRRR          NN     NN     000000     WW     WW     !!
#  FFFFFFFF    00000000    RRRRRRRR        NNNN   NN    00000000    WW WW WW     !!
#  FF          00    00    RR    RR        NN NN  NN    00    00    WW WW WW     !!
#  FFFFFFF     00    00    RRRRRRR         NN NN  NN    00    00    WW WW WW     !!
#  FF          00    00    RR   RR         NN NN  NN    00    00    WW WW WW     !!
#  FF          00000000    RR    RR        NN  NNNN    00000000    WWWWWWWW
#  FF           000000     RR     RR       NN    NN     000000      WWWWWW      00
!
```

VITA

Captain Frank W. DeMarco was born on 8 June 1954 in Wheeling, West Virginia. He graduated from St. Johns High School in Bellaire, Ohio, in 1972 and entered the Air Force at the age of eighteen. He was honorably discharged from the Air Force in 1976 and joined the Ohio Air National Guard. In 1978 he joined the Air Force Reserve Officer Training Corps at Ohio University in Athens, Ohio. He received the degree of Bachelor of Science in Education (Mathematics) in June of 1980. Upon graduation, he received his commission in the USAF. Entering active duty in July 1980 he was assigned to the 3300 Technical Training Wing (TCHTW) at Keesler AFB, Mississippi. His duties while at Keesler included working as a World Wide Miltary Command and Control System (WWMCCS) mobile training team member and as a course writer for the Computer Assisted Instruction (CAI) Plans Branch of the 3300 TCHTW. In May of 1984 he entered the School of Engineering, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

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Thesis Chairman: Dr. Henry B. Potoczny

Professor of Mathematics

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The field known as "computer assisted instruction" or CAI as it is commonly called, has gained considerable interest and support since the advent of the microcomputer. More and more people, including those in supervisory positions are beginning to see the advantages, both cost and time, in having training available in the workplace. This study developed a training package for use on the Zenith Z-100 microcomputer. The package consists of six lessons and three programs. The six lessons cover various topics dealing with the "C" programming language. The objective of these lessons is to present an introduction to the "C" programming language. The three programs are written in the Pascal programming language and are used for the following functions:

1. Provide a means of displaying the lesson material.
2. Provide a means of checking student progress.
3. Provide a means of displaying course statistics.

END

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DTIC